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PHYTOPATHOLGOY

VOLUME XIV NUMBER 7

JULY, 1924

APPLE MEASLES, WITH SPECIAL REFERENCE TO THE COMPARATIVE SUSCEPTIBILITY AND RESISTANCE OF APPLE VARIETIES TO THIS DISEASE IN MISSOURI

ARTHUR S. RHOADS

WITH PLATES XVII TO XXI AND ONE FIGURE IN THE TEXT

INTRODUCTION

Since its report and description in Arkansas in 1912, apple measles has been reported from a number of states and appears to be a disease of widespread occurrence that is gradually attracting an increasing amount of attention. This disease, which has been made the subject of two contributions from the Missouri State Fruit Experiment Station (15, 16), is of such common occurrence in the orchards of this station and in those of other sections of the state that the writer began an investigation of it at the beginning of 1923. However, inasmuch as he has accepted another position in a totally different line of investigational work, no further attention can be given this problem. It has been deemed advisable, therefore, to sum up briefly the investigational work thus far done on this disease and to present the work of the writer.

HISTORICAL

Apple measles was first described by Hewitt and Truax (12) from Arkansas in 1912, where it was observed first in 1908. The disease was given the very appropriate name of "measles" and two forms of it were described, namely the pimply or pustular type and the scurfy type. No organism was found which could be definitely considered as the cause of this trouble.

Apple measles was reported next in 1914 by Rose (15), who called it "pimple canker" and states that it had been known at the Missouri State Fruit Experiment Station since about 1904. He describes and illustrates both the pimply and the scurfy types of the disease, calling the latter "scurfy canker" or "rough-bark canker." In the later paper by Rose (16) the rough-bark or scurfy bark type of measles is described in detail and evidence presented that it is caused by one or more forms of bacteria which appear to be the same as the one causing a blister-spot on the fruit of certain varieties of apples.

Adams (1) reports the occurrence of apple measles in Pennsylvania in 1916, giving notes on the same and illustrating the occurrence of this disease on a limb of a Smith Cider tree.

Subsequent reports of apple measles from a number of states are mentioned in several numbers of "The Plant Disease Bulletin" issued by the U. S. Department of Agriculture. Hesler and Haskell (11, p. 18) mention a report that it was local in Pennsylvania and that there the Smith Cider appeared to be the most susceptible variety. They also mention a report from Ohio of a "pimple disease" on apple, which the writer assumes is but another name for measles. Hutchins and Haskell (13, p. 137) state that Leonian reports measles to be common and destructive in New Mexico and that Virginia reported it from Patrick County. Anderson (3, p. 61) states that Leonian reports measles to be quite a serious apple trouble throughout New Mexico. Haskell and Wood (10, p. 51–52) give a resumé of the apple measle situation up to that time. They state that since its first report from Arkansas it has been reported from Pennsylvania, Maryland, Virginia, Alabama, Michigan, Arkansas, New Mexico, Illinois, and Kansas, but neglect to include Missouri. Except for New Mexico they believe the disease to be local and of little importance. The Plant Disease Survey (14, p. 106) mentions a report by Sherwood that apple measles is increasing and apparently causing considerable damage in certain sections of southeastern West Virginia.

Brief reports of the progress of investigations on apple measles in New Mexico occur in the annual reports of the New Mexico Agricultural Experiment Station (4, 5, 6, 7). In the report for 1920–1921 (5) a very comprehensive program of investigational work on this disease is outlined and it is stated that measles has been reported from every apple-growing section in New Mexico, as well as southwestern Texas. It is also reported as occurring in Colorado and South Carolina. A popular account of this disease in New Mexico is given later by Archer (8).

DESCRIPTION OF APPLE MEASLES

Macroscopic description.—The disease known as apple measles is extremely variable in its occurrence. In general it may be stated that there are three more or less distinct types of the disease. As a matter of convenience these may be designated as the isolated pustular type, the aggregate pustular or scurfy type and the canker type. There may be various gradations between the first and the second and, less frequently, between the second and the third of these so-called types, depending somewhat on the stage of development of the disease and the variety affected.

In the isolated pustular type more or less numerous reddish to chestnut brown pustules may occur on the smooth bark of the twigs and young

branches, varying from sparse to dense infestations, as illustrated in plate XVIII, A. This type of the disease has been observed most frequently on York Imperial trees, although the other two types may also occur on this variety. These pustules are generally a light red near the circumference and chestnut brown toward the summit. Superficially htey closely resemble fungous pycnidia, but microscopic examination shows the resemblance to be merely superficial. As a rule the pustules average about 1/32 of an inch in diameter and about half of their diameter in height. Occasionally, as on the limbs of the Family apple tree illustrated in plate XVII, B, they may have a basal diameter of as much as 1/8 of an inch. The larger pustules at least, due to the unequal tensions arising in the growth of the twig or branch, may split open radially, or they may tend to split basally from the underlying bark, as is shown in plate XVII, B. If a thin shaving be cut from the surface of the cortex with a sharp knife or razor the cut surface is spotted with dark spots according to the number of pustules cut through. As a rule the pustules do not extend inward more than a third of the distance to the cambium, and in no case have they been noted to extend more than about half way in to the cambium.

In certain other phases of the disease the pustules become more numerous and often densely crowded until small areas of the twigs and young branches, or often large areas of the same, have a densely pimply or finely pustular appearance and the whole area of the affected bark becomes irregularly thickened. The thickened bark acquires a darker coloration than the normal bark, becoming reddish brown to blackish and often with a purplish tinge. Occasionally the thickening of the bark is nearly uniform, but usually it is very uneven, giving the appearance of having been formed by the coalescence of a large number of pustules. Some of these nearly uniformly thickened blackish areas of bark often may be confused with a similar type of bark often occurring around blotch infections, but usually are much more extensive and do not exhibit the cracking of the bark with pycnidia as does the blotch. The above type of the disease, which is much more prevalent than the isolated pustular type, may be termed the aggregate pustular or scurfy type since the densely pustular areas of thickened bark give the twigs and branches much the appearance of being covered with a scurf. This is the type of the disease so commonly found on Beach (Plate XVII, A) and Summer Champion trees. On these varieties the pustular thickened areas of bark very frequently have their inception at the nodes, although they also may start at some point along the internodes. After a time the bark that has become densely pustular or scurfy begins to crack and peel off, sometimes in very fine scales, as in Beach, but more often in quite prominent ones, as is shown at the right in plate XIX. Frequently the outer,

densely pustular portion of the bark at the bases of young trees will slough off in heavy scales at an early age (Plate XXI).

Very frequently there occur on the smooth bark of the limbs and trunks of affected trees more or less localized areas of densely pustular bark of the aggregate pustular or scurfy type that soon become roughened and scaly. Owing to the rather sharply demarked limits of these roughened areas of bark they closely resemble cankers and therefore have been designated by the writer as measle cankers. As a rule measle canker formations do not occur on young trees. The case of the heavy bark scaling on the trunk of the tree shown in plate XXI, while morphologically the same as the scaling of the bark on the branches illustrated in plate XIX, is not termed a measle canker because the limits of the affected bark are not sharply defined as are those of the limbs illustrated in plate XIX (in the limb at the right the distal ends of the diseased bark are not shown). As was stated before, however, many gradations are to be found between these arbitrarily determined types. In many varieties the measle canker formation is the only evidence of the disease that the trees exhibit. These cankers usually occur on the branches but sometimes occur at various points on the trunk from the base to the crotch of the scaffold limbs. When occurring at the latter point the cankers usually extend up onto the scaffold limbs. Such mode of infection was noted in Black Annette, Ingram, Iowa Beauty, Isham, Lybyer No. 1, Texas County Seedling, Yellow Transparent, and Wealthy.

The earlier stages of measle canker formation, consisting of densely pustular and irregularly thickened bark areas, or of the same after the pustular layers of the bark have begun to crack, loosen and scale off (Plate XIX, left), are seen much less frequently than the older stages where the outer layer of the pustular bark has become cracked and is in various stages of sloughing off (Plate XIX, right). Where the measled bark has practically all sloughed off the more or less pimply bark usually found at the margins of the bark cankers furnishes the tell-tale signs of measles (Plate XVII, C). However, in other cases where the pustules extend into the bark but very superficially the entire pustular portion of the bark soon sloughs off very completely, leaving behind a smooth layer of bark without even a trace of pustule formation at the margin. This complete exfoliation of the outer diseased bark indicates that the tree has outgrown the disease. This occurs very quickly in small cankers in which the pustules extend into the bark but very superficially, but in those in which the pustules extend in rather deeply the evidence of measles may persist for several years. In the case of an Evans tree the roughened scaling bark of the measle canker still could be seen plainly on a 4½-inch limb. It is very exceptional, however, to find measle cankers still in evidence on limbs of this size inasmuch as the normal processes of bark scaling, which occur sooner or later on the older

stem portions, tend to obscure and obliterate the measle canker formation.

A well illustrated description of the process of bark scaling occurring in the measle cankers has been given by Rose (16), who terms this form of the disease the rough-bark or scurfy-bark canker. He states that these cankers usually are found on the north side of a limb and that, with few exceptions, they are bordered by a pimpled ridge slightly more brown than the healthy bark around them (Plate XVII, C). Rose also states that the active stage of the disease occurs in the early spring and reaches its extreme form on certain varieties of dwarf apples, but that it has been observed on Logan, Munson, Ben Davis, and several others. His description is quoted in the following:

> In the development of this active stage, the first change visible from the outside is the formation of narrow cracks, 1.0 to 1.5 mm. deep by 5 to 20 cm. long, about 1 cm. outside of the pimply ridge referred to above. Inside of these cracks the bark is found loosened—as early as March 21, 1916—in a layer about 2 mm. deep. It is easily peeled off and if this be done there is revealed a spongy layer of giant cells about 1 mm. thick, which is white or greenish white at first, but which soon oxidizes to a pale brown and later to a dark brown color. Under natural conditions the loosened outer layer begins to dry and curl slightly within a few days after the cracks are formed; as a consequence the cracks widen, air circulates more freely under the loosened layer and the spongy layer dries down. Within two weeks from the time the cracks first show there is usually no spongy layer to be found and the loosened layer has become dried, curled fragments which break off almost at a touch. Many varieties show no wholesale loosening of the outer bark, but merely a scaling off of small patches without the formation of a definite spongy layer. Sometimes the dry, brown vestiges of such a layer can be found, sometimes not. Possibly in such cases it develops slowly and progressively from one point to another, loosening the bark only a little at a time and drying down almost immediately.

In the numerous measle cankers studied by the writer, however, no such process of bark scaling in which the bark becomes loosened by the formation of a spongy layer of giant cells as described by Rose (15) has been observed. The orchard of dwarf apples for which this process of bark scaling was described and illustrated by Rose was removed a few years ago. The writer is inclined to regard Rose's description of the formation of a spongy layer of giant cells beneath the loosening bark to be analogous to a similar process of bark loosening from an abnormal cell-elongation in the bark parenchyma described by Sorauer (17, pp. 328–331), as a result of the action of a local excess of water. It is not impossible that this pathological condition may have occurred in conjunction with measles. In the many measle cankers studied by the writer the bark scaling resulted only from the formation of cork layers beneath the outer pustular bark.

Measles apparently have their inception only on the fairly young growth, although in the many cases studied by the writer the pustular bark was noted but rarely on the growth of the last year or two, even in very sus-

ceptible varieties. In fact the occurrence of measles on one-year shoots appears very rare, although it has been observed. In the case of larger branches or limbs disposed more or less horizontally there often appears to be a tendency for the measled bark to be confined largely to the upper sides. Both young trees and old ones may exhibit measles and many varieties show unmistakable evidence of having been affected for many years.

Microscopic appearance.—Large numbers of microtome sections were prepared from both imbedded and unimbedded material representing various types of measles in order to study in detail the course of the development of the disease and the pathological anatomy of the diseased bark. In normal apple bark the epidermis is replaced as a tegumentary tissue before the end of the first year by a protective cork layer from 3 to 5 cells deep, which develops from a meristematic layer of phellogen originating on the inner side of the epidermis. This band of cork cells, which represents the primary periderm formation, increases but little in thickness during the course of the next several years, during which it constitutes the external investment of the stem.

In every case observed, where a measle pustule develops this band of cork cells broadens locally, not only as a result of the increase in the number of cells developed beneath the outer layers of cork cells but also as a result of the increased width of these cells as viewed in transverse sections. Like the cells of the protective cork layer normally replacing the epidermis, they are filled with a brown substance which has but little or no affinity for the aniline dyes ordinarily used in staining.

In the fairly distinctly developed pustules there appears to be a rather abrupt transition to still larger and more or less elliptical cells, whose arrangement departs from the radially disposed rows so characteristic of the outermost portion of the bark. The cells at the immediate centers of the individual pustules are thinner-walled than those of the cork layer above; their walls show a strong affinity for cellulose stains, such as Delafield's haematoxylin, and they appear to be parenchymatous in character (Plates XVIII, B; XX, A).

Eventually a layer of cork cells, continuous with the innermost row of cells of the layer of cork replacing the epidermis, develops beneath the tissues of the excrescence, which then become cut off from the underlying cortex. With the continued development of the cork formation beneath the excrescences they tend to become exfoliated.

In the so-called scurfy type of measles, in which the bark becomes so densely pustular that it becomes more or less irregularly thickened over large areas, the general features of pustule formation are essentially the same except that they anastomose more or less extensively and large areas of bark may become involved in the bark exfoliation.

In many varieties, such as the Beach and Summer Champion, the pustules in general always remain characteristically minute and inconspicuous; as a rule they rarely attain the prominence of the one shown in plate XX, A. In other varieties, such as Ingram, Jonathan and York Imperial, in which the pustules as a general rule are characteristically larger and more conspicuous, the layers of cork cells, both above and below the developing pustule, become bowed out by the development of the excrescence, so that in transverse section the smaller types of pustules are lenticular in outline (Plates XVIII, B; XX, A). Or they may enlarge until they become as deep as they are broad and appear more or less circular in outline as viewed in transverse section. In extreme cases of pustule formation, as in the branch

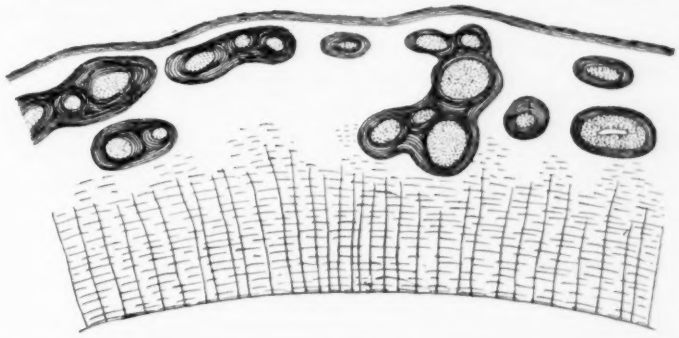

FIG. 1. A semi-diagrammatic camera-lucida drawing of a transverse section through the pustular bark of canker on branch of Jonathan apple tree appearing at left in plate XIX, showing the complete inclusion of old measle pustules, either singly or in groups, in the outer bark and their demarcation from the surrounding cortex by cork layers. The lower shaded portion represents the inner bark or phloem with the medullary rays shown as they actually occurred. × 11.

of the Family apple tree shown in Plate XVII, B, many layers of radially compressed cork cells have developed beneath the original measle pustules so that large and very conspicuous excrescences are formed eventually (Plate XX, B). Here the pustules extend in as far as the outer hard bast bundles.

In still other cases of measles in which the bark has more or less of a lumpy appearance instead of a distinctly pustular one, as in the case of the Jonathan limb shown at the left in plate XIX, large numbers of the pustules often become overgrown in the processes of bark development and remain behind as inclusions in the cortex. These inclusions become walled off from the rest of the surrounding living tissue by a layer of cork developed about them, which is similar to that of the protective layer replacing the epidermis and averages from 10 to 15 cells in thickness (Plate XX, C). Hartig (9) illustrates a similar walling off by cork layers of areas of bark killed by lightning discharge in *Picea excelsa*. In case two or three included

measle pustules closely adjoin one another the wall of cork may develop about the group, dipping inward partially between the individuals (Text figure 1). Many of these inclusions lie near the surface of the bark, while others are more deeply imbedded, being distributed among the outer groups of hard bast fibers. Bundles of bast fibers are often found in the centers of these included tissues.

COMPARATIVE SUSCEPTIBILITY AND RESISTANCE OF APPLE VARIETIES TO MEASLES

We have as yet very meager information concerning the comparative susceptibility and resistance of apple varieties to measles. While Hewitt and Truax (12) give no data on this point, it is evident from their work that Ben Davis, Gano, Givens, Jonathan, and Limbertwig are susceptible varieties. Rose (15) states that the White Winter Pearmain and Beach were severely affected, and that many other varieties also were affected but none of them to any great extent. In his later paper dealing with the scurfy-bark type of measles, Rose (16) states that the disease occurs on such standard varieties as Ben Davis, Jonathan, Logan, White Winter Pearmain, Beach, Stayman Winesap, Munson, and Marsh, but much more severely on certain dwarf varieties. Haskell and Wood (10) state that Pennsylvania reported Smith Cider as the only variety commonly affected, but that Maiden Blush was attacked in 1915. Archer (8) states that the Jonathan seems to be the most susceptible variety in New Mexico, adding that the disease occurs on other varieties but that the damage is negligible. Adams (2) states that measles was reported on Delicious in Kansas in 1922.

At the beginning of 1923 the writer started an intensive reconnaissance study of the several orchards of the Missouri State Fruit Experiment Station in order to determine the extent and severity of apple measles, its forms and mode of occurrence, and to determine the relative susceptibility and resistance of the numerous varieties of apples represented. This reconnaissance was begun during the late winter and was completed before the leaves had begun their development, so that a clear and unobstructed view could be had of all the branches.

The older orchards, represented by the Commercial, East Variety and West Variety Orchards, were studied first. These orchards, which are maintained in sod, were set out in 1902, 1903 and 1904, and replantings made subsequently as the original trees died. A total of 1667 trees was used as a basis for the measle census in these three orchards and many other trees were omitted because there was no record of the variety.

While the paucity of trees of most of the numerous varieties renders it difficult to draw conclusions, it was clearly evident that there are marked

differences in the susceptibility and resistance of different varieties of apples to measles under the same conditions of soil management. It was furthermore evident that many of the susceptible varieties became affected by measles in a manner and extent more or less peculiar to the variety, although some varieties may exhibit all three types of measles. For example, the Beach, Blue Pearmain, King David, Oldenburg, Red Astrachan, Summer Champion, Texas Red, Winter Pearmain, and certain other unknown varieties were characterized by the branches and twigs of many or even all of the trees of some varieties being finely but densely pustular, the pustular condition being of such widespread occurrence that the limbs, branches and twigs appeared scurfy in general. In these varieties the bark on the older limbs eventually becomes finely scaly and measle canker formations rarely occur. In still other varieties, such as the Elkhorn, the measled appearance was the same except that the pustules were larger and more conspicuous. The only Family apple tree present was characterized by unusually large and prominent corky pustules varying from sparse to dense infestations. Some York Imperial and Jonathan trees may show only occasional isolated pustules, while others, or perhaps other branches of the same tree, may show patches of them or scurfy areas of bark, and sometimes canker formations also. The majority of the susceptible varieties, however, merely exhibited measle canker or else occasional pustular patches of the scurfy type on the limbs, or sometimes both. As a rule the measle cankers averaged from 1 to 5 per tree and appeared to be of no consequence in so far as the health of the tree was concerned. However, a few varieties like Heiges, Logan, Munson, and Whitney (crab) proved especially susceptible to this form of measles, the trees commonly having 10, and occasionally as many as 20, cankers on the limbs. As a rule these cankers consisted of long scaly bark areas usually extending entirely around the branches. These cankers were commonly a foot, and sometimes nearly three feet, in length.

It was believed that a reconnaissance of the station's North Commercial and Pruning Orchards, which are divided into a number of different soil management plots, would indicate whether or not any relation exists between soil moisture, fertilization or pruning and the occurrence of apple measles. The North Commercial Orchard was set out in 1921, the soil management plots running at right angles to the variety rows, of which the first four are York Imperial, the next four Willow, the next four Jonathan, the next three Golden Delicious, and the last three Rome Beauty. In 1922 an additional ten trees were interplanted in plots E to J of each variety row for temporary study, making a total of 986 trees in this orchard. Unfortunately for the point to be determined, the York Imperial was practically the only variety that exhibited much in the way of measles. Of a total of 228 trees of this variety 74 exhibited more or less of a measled

appearance, varying from a few pustules on the branches and twigs to a fairly general densely pustular condition of the trunks, branches and twigs. Only 2 of the 228 Willow trees and 3 of the 228 Jonathan trees exhibited a measled condition, and no evidence of this trouble was noted on any of the 155 Golden Delicious and 147 Rome Beauty trees. The number of measled York Imperial trees on any one of the special treatment plots varied within the limits of the number of measled trees on the various check plots and no relation between apple measles and soil management was apparent.

The same situation was found to hold for the Pruning Orchard, which was set in the spring of 1919. This orchard consists of 17 rows of different varieties, with 47 trees in each row except the first (Golden Winesap), which has but 20. Two of the rows were replanted in 1922 to Payne and McIntosh. There is a total of 772 trees in this orchard. The pruning and soil management plots run at right angles to the variety rows. No evidence of measles was noted on any of the trees in the rows of Golden Winesap, Winesap, Paragon, Arkansas Black, Willow, Rome Beauty, Stayman Winesap, Ingram, Black Ben Davis, Payne, and McIntosh. In the remaining rows of 47 trees each the number of trees affected by measles was as follows: Collins, 3; York Imperial, 45; Grimes, 1; Jonathan, 9; King David, 43; Delicious, 8. Here, just as in the North Commercial Orchard, no relation was to be observed between measles and the mode of soil management, nor the mode or severity of pruning. In both these orchards measles appeared to be related only to the variety of the tree and this relation appeared to be a very clean cut one.

The station's Summer Orchard, which is maintained in clean cultivation, was set out in 1919 and originally contained 22 rows of 10 trees each. However, many had died and were replanted in 1920 and 1921. Of the 185 trees used as a basis for the measle census of this orchard the following number of each variety exhibited measles: Yellow Transparent, 5 out of 10; Carson, 1 out of 10; Colton, 1 out of 10; Chenango, 1 out of 8; Summer Champion, 4 out of 9; Wealthy, 2 out of 10. No evidence of measles was noted on the remaining trees, among which were the following: 10 each of Early Harvest, Liveland, Oldenburg, Benoni, Maiden Blush, Red Astrachan, Skelton, Williams, Red June, Eades, and Ada Red; 3 of Lowell; 6 of Wilson June; 3 of Sops-of-wine; and 3 of Fanny.

In the station's Stock and Scion Orchard, which was set out in 1920 and 1921, and which is maintained in clean cultivation, 234 trees were examined. Only one of the Stayman Winesap trees exhibited measles out of the following: 22 each of Virginia Crab, Transcendent Crab, Walbridge, Hibernal, Minkler, Mammoth Black Twig, Henry Clay, Peerless, and Lilly; 8 Ingram; 7 Stayman Winesap; 7 Grimes; and 14 Mann.

In the station's Top-worked Orchard, which is maintained in sod, but

little of any general interest on measles was noted. The portion remaining at the time of the reconnaissance consisted largely of Ben Davis-Jonathan crosses, unknown varieties and trees top-worked with one or more varieties. Among the latter one tree top-worked with Matt Seedling and one with Reinette Clermontois exhibited measle cankers on the limbs. Another tree top-worked with Cox Orange below and Arlington above exhibited numerous large measle pustules on the limbs and branches, and smaller ones on the twigs practically throughout the entire tree, with the bark becoming finely scaly on many limbs.

Two test orchards of seedling trees, most of which had come into bearing, also were examined and many trees were found to exhibit measles in varying degrees. These trees were crosses between various varieties, but mostly between Ben Davis and Jonathan. Of the unnamed chance seedling trees in the orchards of the station 7 out of 21 seedlings representing 30 trees were affected by measles in varying degrees.

The reconnaissance of the young orchards affords additional strength for the opinion formulated from that of the old orchards that there are marked differences in the susceptibility and resistance of different varieties of apples to measles under the same conditions of soil and management. Tree age does not appear to be a determining factor in the occurrence of measles for in many of the varieties both young and old trees exhibited the trouble, and many of the latter clearly have been affected for several years. However, in a few varieties, namely Arkansas Black, Black Ben Davis, Hibernal, Minkler, Oldenburg, Red June, Skelton, Tolman, Wealthy, Williams, Wilson June, Winesap, and Winter Paradise, measles was noted on the old trees but not in the young ones.

In table 1 a list of all the known varieties of apples in the orchards of the Missouri State Fruit Experiment Station exhibiting measles is given, the character of the disease exhibited being classified into two more or less broad types, namely the pustular type, covering all gradations between the closely allied isolated pustular type and the aggregate pustular or scurfy type, and the canker type. In case the trees of any one variety exhibited both of these types of measles an asterisk is placed in each column and the type predominating, if either, marked with two asterisks.

It is not claimed that the varieties in the list below are not susceptible to measles because the number of trees of practically all of them is far too small to justify this conclusion. In the field reconnaissance it was noted that a few varieties that did not exhibit measles in one orchard did in another. Further studies of trees of the varieties in this list will undoubtedly show that several of them are susceptible to measles. In fact, of the varieties listed in table 2, two have been reported to be affected by measles, namely the Limbertwig in Arkansas, by Hewitt and Truax (12), and the

TABLE 1.—*Varieties of apples in orchards of Missouri State Fruit Experiment Station exhibiting measles.*[1]

Variety of tree	Number Present	Number Affected	Type of measles exhibited	
			Pustular type	Canker type
Akin	1	1	*	
Alexander	2	2	*	**
Arkansas	8	4		*
Arkansas Black	50	3		*
Arlington (topworked)	1	1	*	
Ashton	1	1		*
Autumn Cranberry	2	1		*
Autumn Sweet Swaar	2	2		*
Babbitt	2	2	*	**
Baker	2	2		*
Baxter	3	2		*
Beach	19	19	*	
Belmont	2	2	*	
Ben Davis	75	14		*
Ben Hur	4	2		*
Bentley	2	2		*
Black Annette	2	2		*
Black Ben Davis	67	10		*
Blue Pearmain	2	2	*	
Bonum	2	2		*
Boskoop	1	1		*
Bryan	3	1	*	
Buckingham	4	2		*
Buncombe	3	3		*
Calvert	2	1	*	
Carson	10	1		*
Chase Blush (crab)	2	1		*
Chenango	15	1	*	
Cleopatra	2	2		*
Coffelt	1	1		*
Coffman	3	1		*
Collins	118	16	*	**
Colton	15	2	*	*
Cox Orange (topworked)	1	1	*	
Delicious	62	10	*	
Early May	3	3	*	**
Early Melon	2	1		*
Elkhorn	3	3	*	
English Russet	4	3		*

[1] The nomenclature for apple varieties here listed is that of Beach (The Apples of New York, Volumes I and II, Ann. Rept. N. Y. (State) Agr. Exp. Sta., 1903, 1905) and Regan (Nomenclature of the Apple; a catalogue of the known varieties referred to in American publications from 1804 to 1904, U. S. Dept. Agr., Bur. Plant Ind. Bul. 56, 1905). A few varieties not found in these publications are of foreign origin or American varieties that at present are not grown to any extent commercially.

TABLE 1.—(*Continued.*)

Variety of tree	Number Present	Number Affected	Type of measles exhibited	
			Pustular type	Canker type
Esopus	6	2	*	*
Evans	4	2		*
Excelsior (crab)	1	1		*
Fall Pippin	5	2		*
Fall Queen	1	1		*
Fall Stripe	2	2		*
Family	1	1	*	
Gano	4	1		*
Garden Seedling	6	6		*
Gilpin	8	1		*
Givens	45	27	*	**
Gladstone	2	2		*
Golden Russet	2	2		*
Gravenstein	4	3		*
Green Sweet	1	1		*
Grimes	75	1	*	
Hawley	2	2		*
Hargrove	3	3	*	
Hastings Red	1	1		*
Heiges	38	38	*	**
Hibernal	25	3		*
Highfill	5	3		*
Hightop Sweet	3	2		*
Holbert	3	1		*
Holley	1	1		*
Holman	3	3		*
Holt	11	2	*	**
Hoover	4	4		*
Hubbardston	1	1		*
Hurne	5	1		*
Hyslop (crab)	4	2		*
Ingram	126	16	*	**
Iowa Beauty	1	1		*
Isham	2	1		*
Ishewood	3	3		*
Ishmaelite	2	2	*	*
Jacob	1	1	*	
Jersey Sweet	3	2		*
Johnsonite	1	1		*
Jonathan	372	37	*	**
Kentucky Red (crab)	3	1		*
King	6	1		*
King David	52	48	*	
Kinnard	12	2	*	*
Kittageskee	3	2	*	
Kooroochiang (U. S. D. A. buds)	2	1		*
Langford	3	3		*
Lansingburg	8	2		*
Lawver	5	2		*

TABLE 1.—(*Continued.*)

Variety of tree	Number Present	Number Affected	Type of measles exhibited	
			Pustular type	Canker type
Logan	11	10		*
Loy	5	3		*
Lybyer No. 1 (Seedling from Dykes, Mo.)	7	3		*
Lybyer No. 2 (Seedling from Dykes, Mo.)	2	1		*
Malinda	6	3		*
Mamma	3	2		*
Margaret	3	1		*
Marsh	3	3	*	**
Martin	3	3		*
Matt Seedling (topworked)	3	1		*
Maxon's Early	2	1	*	
Milam	2	2		*
Minkler	41	6		*
Mock	2	1	*	*
Monsees	5	1		*
Moore's Black	2	1		*
Mother	22	5	*	*
Munson	2	2		*
McAfee	5	2		*
McMahon White	2	1		*
Neuer Englisher Pigeon	1	1		*
Nickajack	6	3		*
Nixonite	5	1		*
Nordhaussan	3	1		*
Northern Spy	4	1		*
Northwestern Greening	4	1		*
Ohio Nonpareil	2	2		*
Oldenburg	14	4	**	*
Ontario	1	1		*
Ozone	17	1	*	*
Pennock	2	1		*
Pewaukee	3	3		*
Pilot	3	2		*
Plumb Cider	3	1		*
Popoff	2	1		*
Porter	2	2		*
Powers	2	2	*	
Price Sweet	1	1		*
Quaker Beauty	1	1		*
Queen	2	2		*
Ralls	9	5		*
Rambo	9	1	*	
Red Astrachan	16	5	*	
Red Belle Fleur	1	1		*
Red June	11	1	*	*
Reinette Clermontois (topworked)	2	1		*
Roxbury	1	1		*
Salome	4	1		*
Sandbrook	2	2	*	

TABLE 1.—(*Continued.*)

Variety of tree	Number Present	Number Affected	Type of measles exhibited	
			Pustular type	Canker type
San Jacinto	4	2		*
Schroeder	1	1		*
Shannon	2	2		*
Shannon Improved	12	2		*
Sharp's Nonesuch (U. S. D. A. buds)	1	1	*	*
Shirley	6	2	*	*
Skelton	16	3		*
Smith Cider	2	2	*	
Stayman Winesap	58	4	*	**
St. Lawrence	2	1		*
St. Louis	8	3		*
Summer Champion	21	16	*	
Summer Rambo	1	1	*	*
Sweet Pear	1	1		*
Tanhaki (U. S. D. A. buds)	2	2	*	
Texas County Seedling (from Texas Co., Mo.)	62	31	**	*
Texas Red	2	2	*	
Tolman	14	5	*	*
Tunnell	2	1		*
Twenty Ounce	2	1		*
Utter	2	2		*
Victuals and Drink	2	2		*
Wandering Spy	2	1		*
Wealthy	13	3	*	**
Western Beauty	1	1		*
West Plains Seedling (from West Plains, Mo.)	6	2		*
Whitney (crab)	6	5		
Williams	15	1	*	
Willow	279	2	*	
Wilson June	11	2		*
Winesap	64	7		*
Winter Paradise	12	2		*
Winter Pearmain	2	2		*
Wolf River	6	3		*
Yellow Horse	3	1		*
Yellow Newtown	6	4	*	
Yellow Transparent	14	6	*	**
Yarra Bank (U. S. D. A. buds)	1	1	*	
Yates	6	6	*	*
York Imperial	338	147	**	*
Total	2656	763		

Maiden Blush in Pennsylvania, by Haskell and Wood (10). With these two changes in mind, the lists given in these two tables should prove valuable as temporary check lists in future studies of this disease. In general it may be said that Gold, Grimes, Oliver, and the majority of the true crab apples appear to be very resistant to measles.

TABLE 2.—*Varieties of apples in orchards of Missouri State Fruit Experiment Station not exhibiting measles.*

Variety of tree	Number Present	Variety of tree	Number Present
Ada Red	10	Giant Jeniton	1
Albermarle	1	Gideon	3
Alexis (crab)	1	Gloria Mundi	5
Anoka apple (crab)	3	Gold	19
Amur (crab)	2	Golden Delicious	155
Baldwin	5	Golden Queen	4
Banana	5	Golden Sweet	1
Benoni	12	Golden Winesap	20
Bietingheimer	3	Greenville	7
Bismarck	2	Grindstone	1
Black Burgess	1	Haas	2
Black Oxford	3	Henry Clay	24
Black Warrior	3	Herkimer	1
Bledsoe	2	Higgin Botham (seedling from Olden, Mo.)	2
Blood Red	3	Hopa Red-flower Crab	1
Boiken	2	Horn	5
Broome	1	Howard Sweet	2
Burk	1	Imperial Rambo	1
Capitola	2	Irish Peach	1
Carolina Greening	1	Jefferis	2
Carolina Watson	1	John Sharp (U. S. D. A. buds No. 21722)	1
Carter Blue	1	Kaump	3
Cathay (crab)	2	Lady Sweet	4
Chance	1	Lilly	25
Chicago	5	Limbertwig	2
Cliff Seedling (U. S. D. A. buds)	1	Liveland	10
Clinton	1	Longfield	3
Cooper Market	3	Lowell	7
Cornell	1	Lybyer No. 3 (seedling from Dykes, Mo.)	1
Danvers	1	Magg's Seedling (U. S. D. A. buds)	1
Dees No. 2 (seedling from Arkansas)	2	Maiden Blush	13
De Verike	1	Mammoth Black Twig	22
Dolgo (crab)	3	Mammoth Grimes	2
Domine	2	Mangum	3
Duling	1	Mann	18
Eades	10	Martha	2
Early Harvest	12	Matthews	2
Early Ripe	1	May Pippin	1
Estalline	2	Milwaukee	3
Fallawater	1	Montgomery	1
Fall Winesap	3	Missouri (crab)	2
Fanny	9	Missouri Wild Crab	3
Fletcher	1	Montral Beauty (crab)	1
Florence (crab)	7		
Fulton	5		
General Grant (crab)	1		

TABLE 2—(*Continued*)

Variety of tree	Number Present	Variety of tree	Number Present
McIntosh	54	Scott Winter	3
Nocalyx Crab	1	Shockley	1
Odessa (crab)	3	Simmons Red	3
Olga (crab)	1	Smokehouse	1
Oliver	20	Sops-of-wine	5
Paradise Sweet	1	Soulard (crab)	3
Page (crab)	2	Springdale	1
Paragon	47	Stark	3
Patten	4	Starr	1
Payne	52	Steele Red	1
Peck	1	Striped Pippin	1
Peerless	25	Summer Pearmain	2
Peter	3	Summer Queen	2
Pine Stump	2	Sweet Bough	8
Poorhouse	2	Takapuna	1
Pound Sweet	3	Tippin Seedling (from G. T. Tippin, Springfield, Mo.)	6
Primate	2	Trader	2
Princess Sweet	1	Transcendent (crab)	26
Pumpkin Sweet	3	Ulster	1
Quaker (crab)	1	University	1
Quince (of Cole)	3	U. S. D. A. No. 37568	1
Ramsdell Sweet	3	U. S. D. A. No. 37717	1
Raspberry	3	U. S. D. A. No. 37849	1
Red Siberian (crab)	6	U. S. D. A. No. 38102	1
Red Tip Crab	2	Vandevere	3
Reinette de Besins	1	Van Wyck (crab)	3
Renssalaer	1	Virginia (crab)	25
Rhode Island (Greening)	2	Wagener	4
Ripen de Londies	1	Wallace Howard	1
Robinson	2	Walbridge	24
Rolfe	4	Westchester	1
Rome Beauty	200	White Pippin	2
Rome (Illinois Red)	2	Winterstein	1
Rome (Ohio Dark Red)	2	Yellow Bell	2
Ronge de Nieman	1	Yellow Bellflower	3
Royal Limbertwig	2	Yellow Siberian (crab)	4
Ruby Pearmain	1	York Stripe	3
Rutherford	8		
Rutledge	1		
Saratoga	1	Total	1155
Schoharie	1		

THE CAUSE OF APPLE MEASLES

While a number of widely differing opinions have been advanced to explain the cause of apple measles, no satisfactory and convincing explana-

tion has yet been made and substantiated. Some think bacteria are responsible for it; others suggest unfavorable soil conditions, while still others advance the theory of physiological disturbance. However, there is but scanty experimental data supporting any of these theories.

Hewitt and Truax (12), whose attempts to isolate a fungus or bacterial organism resulted negatively, were of the opinion that apple measles is wholly a physiological trouble. The only inference of a cause with any apparent basis was the possibility that it might be an abnormal lenticel development in which the lenticels, when forming, become diverted from their normal development in such a fashion that layer after layer of cork is formed instead of the ordinary spongy tissue with only occasional corky layers. They regard this inference as supported by the apparent relation between the relative number of lenticels and pustules, the number of lenticels appearing to decrease as the number of pustules increases. As a basis for this relation they present the counts of the lenticels and pustules on one-foot lengths of 45 branches ranging from $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter and representing relatively mild cases of the isolated pustular type of measles on four varieties, namely Ben Davis, Gano, Givens, and Jonathan.

Rose's paper (16), in which the rough-bark or scurfy-bark type of measles is described in detail and in which evidence is presented that this disease is caused by one or two forms of bacteria which appeared to be the same as the one causing a blister-spot on the fruit of certain varieties of apples, seems to have been overlooked by most workers on apple measles. He isolated from various parts of the roughened bark a bacterial organism, very similar morphologically to the blister-spot organism but which upon further study appeared to consist of two different organisms or possibly of two closely related but distinct varieties. One of them, represented by five strains, showed great similarity in morphological and cultural characteristics to the blister-spot organism; the other, represented by 15 strains, resembled the blister-spot morphologically but differed from it in cultural characteristics. Inoculation of bark with the latter organism or variety of organism, which liquefied gelatine rapidly, produced swollen spots 1 to 2 mm. high and covering an area of roughly 1 sq. cm. At these swellings the typical signs of the disease were reproduced, in miniature, and an organism was recovered which agreed in cultural and morphological characteristics with the one used for inoculation. Typical blister spots on the fruit were produced by inoculating Jonathan and Early Melon apples with both bark organisms and these in turn were recovered from the lesions produced. Rose concludes that the cultural characteristics of the blister-spot organism and the two bark organisms suggest that the differences between them are differences of degree rather than of kind and that all three are possibly merely varieties of one species. He believes that more work is necessary,

however, before the true relationship between the fruit disease and the bark disease can be established.

Adams (1), whose material was associated with trees growing in damp ground or under poor drainage conditions, contrasts the theory of Hewitt and Truax (12) with that advanced by Sorauer (17) to explain the tan disease, and suggests that the conditions favoring these diseases may be the same but that the symptoms manifested may depend upon the parts affected.

According to Haskell and Wood (10), Leonian in New Mexico attributed the disease to an excess of nitrates in the soil, while Coons in Michigan believed it to be due to insect injury to young twigs. They suggest, however, that what is being called measles in various states may be a trouble resulting from various causes. Leonian is quoted by Hutchins and Haskell (13) as stating that the spots in which affected trees grow enlarge from year to year, forming circular areas where only a few plants can grow and the trees invariably become measled. It is stated that soil from these spots, upon analysis, showed the presence of nitrates and carbonates in such large amounts as to be positively injurious to the growing things. Essentially the same account of measles is given in the 30th Annual Report of the New Mexico Agricultural Experiment Station (4), in which it is stated that samples from these spots showed their nitrate content to be as high as two thousand parts in the million and that this large amount of nitrates was believed to be the cause of measles.

In the later reports of the New Mexico Agricultural Experiment Station (6, 7) it is stated that experiments in the laboratory to culture and isolate an organism that might be responsible for apple measles have given negative results. In the latest report of this station (7) it is stated that field work, including inoculations of various types into healthy tissue and various types of grafting, have all failed to show characteristic behavior of parasitic organisms. It is further stated that considerable difficulty has been encountered when trying to use measled wood as stocks, as this wood seems to have but little vitality.

The writer likewise has attempted to isolate a causal organism from the pustular and scurfy types of measled apple bark. For this work he was fortunate in having the assistance of Miss Beatrice White, who previously assisted Dr. Rose in his work (15, 16) at this station. In some cases no organism was secured; in others mixed cultures of bacteria were secured, which were separated in poured plate cultures with the hope that the form or forms described by Rose (16) might be found. In this, however, the writer was disappointed, and before other attempts could be made it became necessary to abandon the work. In fact the writer was even unable to find in the orchards the blister spot disease of apples described by Rose. Examination of numerous sectional preparations of carefully imbedded

material stained in various ways never revealed any mycelium or bacteria within the cells.

The writer has not had the opportunity to conduct a series of experiments designed to determine whether or not measles can be transmitted by grafting. However, a large number of apple grafts made at this station during the winter of 1922–23 were inspected with the hope of finding some of especially susceptible varieties in which the scions might have been taken from measled branches. In this the writer was fortunate for he found two young trees of Summer Champion and five of Beach, the scions for all having been cut from densely measled branches. In one of the Summer Champion trees the bark at the base of the new growth was distinctly measled but no evidence of measles was noted on any of the other trees. Even this single case of the new growth being affected, however, does not necessarily prove that the disease is transmissible for it may have arisen on the new growth from the same cause that induced its development on the trees from which the scions were taken.

The investigations of the writer do not indicate that apple measles is caused by an excessive amount of nitrates in the soil, nor by excessively wet or poorly drained soils. This disease occurs in all the apple orchards of the Missouri State Fruit Experiment Station, including both young and old. It occurs on the well-drained sites as well as on the poorly drained ones, and in both orchards maintained in sod and in clean cultivation. It likewise occurs more or less throughout the apple orchards of the state.

While the writer has observed no relation between the drainage of the soil, the application of fertilizers, tillage and cover crops, or the method of pruning and the prevalence of apple measles, it has been noted that certain varieties of apple trees are peculiarly subject to the disease while others growing under the same conditions appear to be more or less immune to it. The disease known as apple measles has not been reported on any other tree and apparently is peculiar to the apple.

While apple measles clearly is a reaction of the bark to internal disturbances of the equilibrium, it still remains to be demonstrated whether this trouble is caused by some fungous or bacterial organism or by some purely physiological derangement of the normal processes of growth and possibly also of nutrition. That this trouble is not caused by a fungus appears to be reasonably certain. The possible rôle of bacteria as a causal agent appears to be in doubt, the work of Rose being contradictory to that of all others who have investigated this disease. The writer is inclined to regard the trouble as a physiological one.

RELATION OF MEASLES TO THE HEALTH OF THE TREE

The statements in regard to the relation of measles to the health of the tree are also quite contradictory in the different localities from which the

disease has been reported. Hewitt and Truax (12) state that, while but few cases had been found where it could be stated with reasonable certainty that the disease had killed the tree, in nearly all cases the vitality of the tree had been noticeably impaired and in many cases limbs had died apparently as the result of this trouble alone.

The following statements by Rose (15) are of interest in this connection:

> The disease does not work as rapidly as Illinois canker on apple or blight on pear but it does seem, in time, to kill out susceptible varieties. All of the White Winter Pearmain trees in the Station orchard were killed about ten years ago under conditions which indicated pimple canker as the only cause of their death. At present all trees of the Beach variety—Apple of Commerce—are affected. They do not seem to be particularly unhealthy so far as fruit and foliage are concerned but others of this variety have died after several years of attack by the disease. Many other varieties are affected but none of them to any great extent.

In his later paper dealing with the scurfy-bark type of apple measles, Rose (16) says:

> Affected trees are not quickly killed as in the case of Illinois canker . . . but there is no doubt that the peeling off of fresh layers of bark every spring is definitely injurious to the tree, aside from the opportunity given for entrance of canker fungi and various bark insects.

Hutchins and Haskell (13) quote Leonian as reporting from New Mexico that trees affected by measles remain stunted for years and eventually die; also that spots in which affected trees grow enlarge from year to year, forming circular areas where only a few plants can grow and the trees invariably become measled. Essentially the same account is given in the 30th Annual Report of the New Mexico Agricultural Experiment Station (4). In the 32nd Annual Report of this Station (5) it is stated that the affected trees remain dwarfed and that the fruit which they bear is small in size and inferior in quality. It is stated further here that affected trees may linger for years until they die, but that when once seriously affected they cease to have any commercial value. In a later account of apple measles in New Mexico, Archer (8) makes the following statements in regard to the relation of this disease to the health of the tree:

> There is yet no absolute proof that the "Measles" actually kills trees. It is certain that the disease does weaken them so that other pests can attack and kill them. Badly affected trees do not thrive well. Their growth is much reduced, so that they remain dwarfed. Such trees bear but little fruit and this of inferior quality. Seriously affected trees may linger along for years but at their best they are of little or no value.

The writer's observations, which were based upon a large number of

affected trees and varieties, do not indicate that the disease known as measles is responsible for more or less of a rapid decline of the tree as a rule. There does not appear to be any indication of either the dying or the decline of any of the 19 Beach or of the 2 Winter Pearmain trees remaining in the station orchards, although these varieties have long been severely affected and a serious loss of them about 1904 was attributed to measles by Rose (15). Many other varieties, such as the Blue Pearmain, King David, Oldenburg, Red Astrachan, Summer Champion, Texas Red, and one unknown variety bought for Oldenburg, also have exhibited a heavily measled appearance for several years, the bark of practically all the branches and twigs being more or less densely pustular, and yet these trees show no indication of dying, dwarfing, unproductiveness, or even of diminished vigor. In the great majority of the varieties herein recorded as being affected by measles, especially in the majority of those listed as having from one to several rough-bark or canker formations, it is clearly evident that the disease is of practically no consequence is so far as the health of the tree is concerned and that the affected trees ultimately outgrow the disease in many cases.

It is not denied, however, that especially susceptible varieties of trees may not be killed by measles. In the case of the two Munson trees and one each of the Lybyer No. 1 and Texas County seedling trees in the station's West Variety Orchard some of the severely affected branches were dying apparently as a result of measles. The sickly condition of a Colton tree set in 1920 in the Summer Orchard is likewise believed to be due to measles. Of the many measled trees observed by the writer, however, these are the only cases where any dying of the tree or part of the tree was believed to be due to measles, and in some instances attacks by weakly parasitic fungi appeared to be a factor in their decline.

On the other hand, many young and vigorously growing trees appear to be able to overcome the trouble, for several Ingram, Mother and York Imperial trees set in 1918 clearly were heavily measled on the trunk at an early age and yet appeared to have largely outgrown the trouble without any special treatment. It is believed that any method of orchard management that will promote a good, vigorous growth of the trees will prove valuable in controlling apple measles.

SUMMARY

This paper discusses an obscure bark disease of apple trees, which has been variously termed measles, pimple canker, rough- or scurfy-bark canker, and pimple cancer. This disease was reported and described originally in 1912 from Arkansas, where it was observed first in 1908. In 1914 it was reported from Missouri, where it is claimed to have been known since about

1904. Since these reports apple measles, which is gradually attracting an increasing amount of attention, has been reported from Michigan, Ohio, Pennsylvania, Maryland, West Virginia, Virginia, South Carolina, Alabama, Illinois, Kansas, Colorado, Texas, and New Mexico.

The literature on apple measles, which has been brought together for the first time, has been reviewed and discussed, and descriptions are given of both the macroscopic and microscopic characters of the disease. In addition the results of the writer's observations on the comparative susceptibility and resistance of apple varieties to measles in Missouri, the relation of this disease to the health of the tree and its cause are given.

A total of 3811 trees of known varieties and named seedlings was used as a numerical basis for this study. In addition to these trees many trees of unknown variety and several hundred seedling trees, mostly of Ben Davis-Jonathan crosses, were examined. Of a total of 347 known varieties and named seedlings of apple trees in the orchards of the Missouri State Fruit Experiment Station, including the youngest as well as the older trees, 177, or 51 per cent, exhibited measles to a greater or less degree, but mostly of the canker type. Of the 2656 trees comprising the known varieties exhibiting measles 763, or 28 per cent, were affected.

There are marked differences in the suceptibility and resistance of different varieties of apples to measles, certain ones being conspicuously susceptible while others are equally resistant under the same conditions of soil and management. Many of the susceptible varieties become affected by measles in a manner and extent more or less peculiar to the variety. Some varieties, however, like the York Imperial, may exhibit a number of different forms of the disease. Only a comparatively few varieties appear to be markedly susceptible to measles. Among these may be mentioned Beach, Blue Pearmain, King David, Oldenburg, Red Astrachan, Summer Champion, Texas Red, Winter Pearmain, and certain unknown varieties for the scurfy type of the disease, and Heiges, Logan, Munson, and Whitney (crab) for the canker type of the disease. Young York Imperial trees are likewise very susceptible to measles, although the older ones exhibit it less frequently. Of other well known varieties Jonathan appears to be much less susceptible than the York Imperial, and Ingram still less so, while Ben Davis appears to be only slightly susceptible. Among the varieties that appear quite resistant may be mentioned Gold, Grimes, Oliver, and the true crab apples in general.

The several explanations that have been advanced to explain the cause of apple measles in a number of the states from which it has been reported are diverse and contradictory. In Missouri the writer has found no relation between drainage of the soil, the application of fertilizers, tillage and cover crops, or the method of pruning and the prevalence of apple measles. While

this disease clearly is a reaction of the bark to internal disturbances of the equilibrium, the causal agent is still in doubt. The trouble does not appear to be caused by any organism, either fungous or bacterial, but appears to be purely a physiological one.

The statements that have been made in regard to the relation of apple measles to the health of the tree are also quite contradictory in the different localities from which the disease has been reported. The writer's observations of the disease in Missouri do not indicate that it is responsible for more or less of a rapid decline of the tree as a rule. He has observed numerous trees of several varieties which have exhibited a heavily measled appearance for several years and yet show no indication of dying, dwarfing and unproductiveness, or even of diminished vigor, as has been reported for trees affected with measles in some localities. Only in a very few cases observed by the writer has a sickly condition of the tree or the dying of the branches been attributed to measles. In the orchards studied by the writer, measles, as a general rule, do not appear to be of any great consequence in so far as the health of the tree is concerned. Many young and vigorous trees ultimately outgrow the trouble without any special treatment.

MISSOURI STATE FRUIT EXPERIMENT STATION,
MOUNTAIN GROVE, MO.

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EXPLANATION OF PLATES*

PLATE XVII

A.—Measled branches of Beach apple tree, showing the finely pustular condition of the bark characteristic of this and certain other varieties when affected by this disease. The disease has its inception as small pustular patches which commonly, although by no means always, start at the nodes. Natural size.

B.—Pustular type of measles on branch of Family apple tree with unusually large pustules. Natural size.

C.—Portion of measle canker on branch of White Transparent (dwarf) apple tree, showing pimply margin of the roughened scaly bark area. Natural size. (After Rose.)

PLATE XVIII

A.—Pustular type of measles on twigs of York Imperial apple tree set in 1919, showing unusually large pustules varying in occurrence from sparse to dense. × 2.

B.—Transverse section through ruptured measle pustule on one of the twigs illustrated in A, showing the formation of a cork layer beneath the tissues of the pustule. × 90.

PLATE XIX

Two measle cankers that occurred on the same branch of a Jonathan apple tree. The younger canker at the left shows an irregularly thickened, densely pustular condition of the bark, which is just beginning to scale off. On the older canker at the right, the distal ends of which are not shown, evidence of the irregularly thickened densely pustular outer bark can still be seen, although most of it has become loosened and broken up into pieces of various sizes, which are beginning to be exfoliated. Natural size.

PLATE XX

A.—Transverse section through measle pustule on one of the York Imperial twigs illustrated in Plate II, A, showing the formation of a cork layer beneath the tissues of the pustule. × 105.

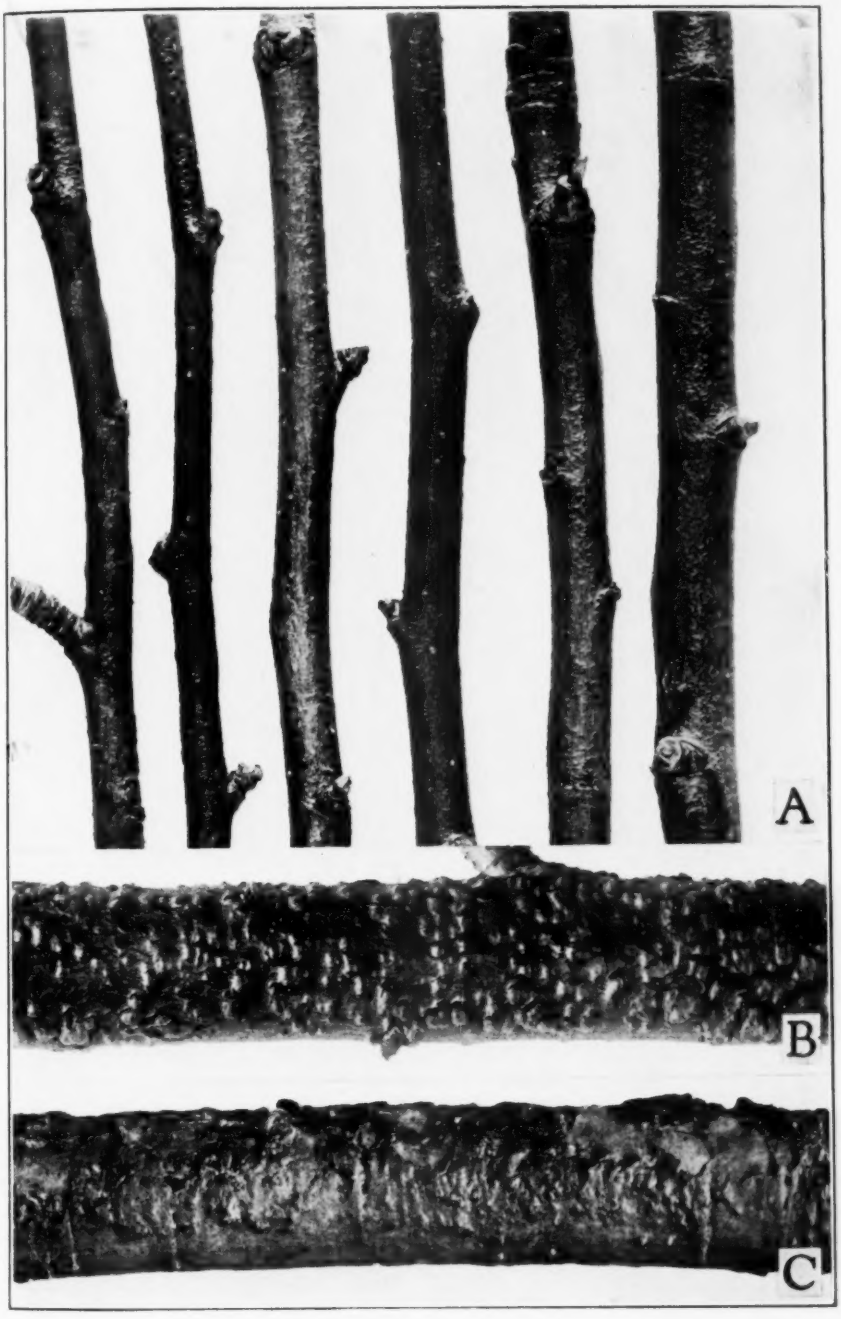
*All photographs, with the exception of Plate I, C, are by the writer.

B.—Transverse section through half of a large corky pustule on the branch of the Family apple tree illustrated in Plate I, B, showing the many corky layers developed beneath the original pustule. × 80.

C.—Transverse section through pustular bark of canker on branch of Jonathan apple tree appearing at left in Plate XIX, showing the inclusion of old measle pustules in the outer bark and their demarcation from the surrounding cortex by cork layers. × 83.

PLATE XXI

A severely measled Esopus (Spitzenburg) tree set in 1913. The bark of the trunk and basal portions of the scaffold limbs was densely and conspicuously pustular, but the outer measled bark of the trunk and one of the scaffolds has begun to exfoliate in deep scales.



APPLE MEASLES

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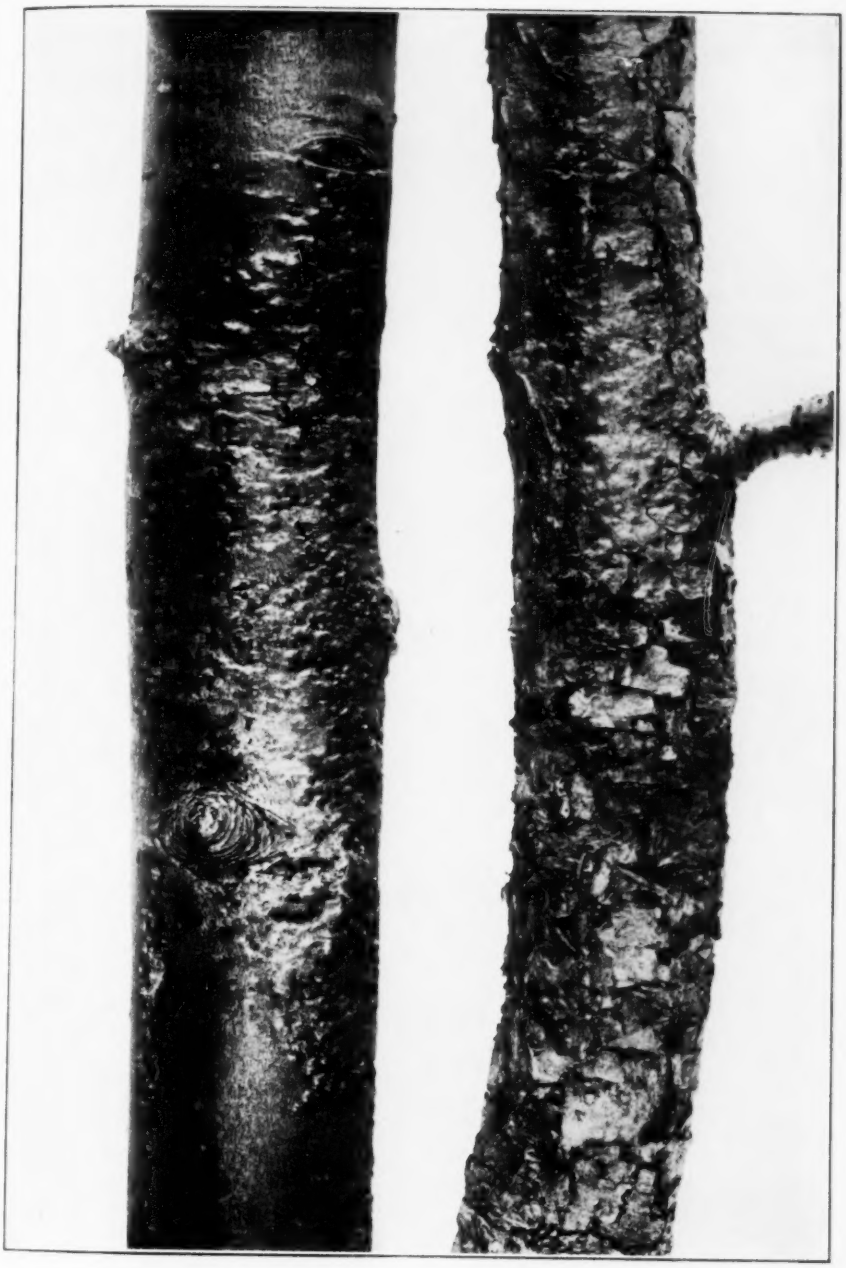

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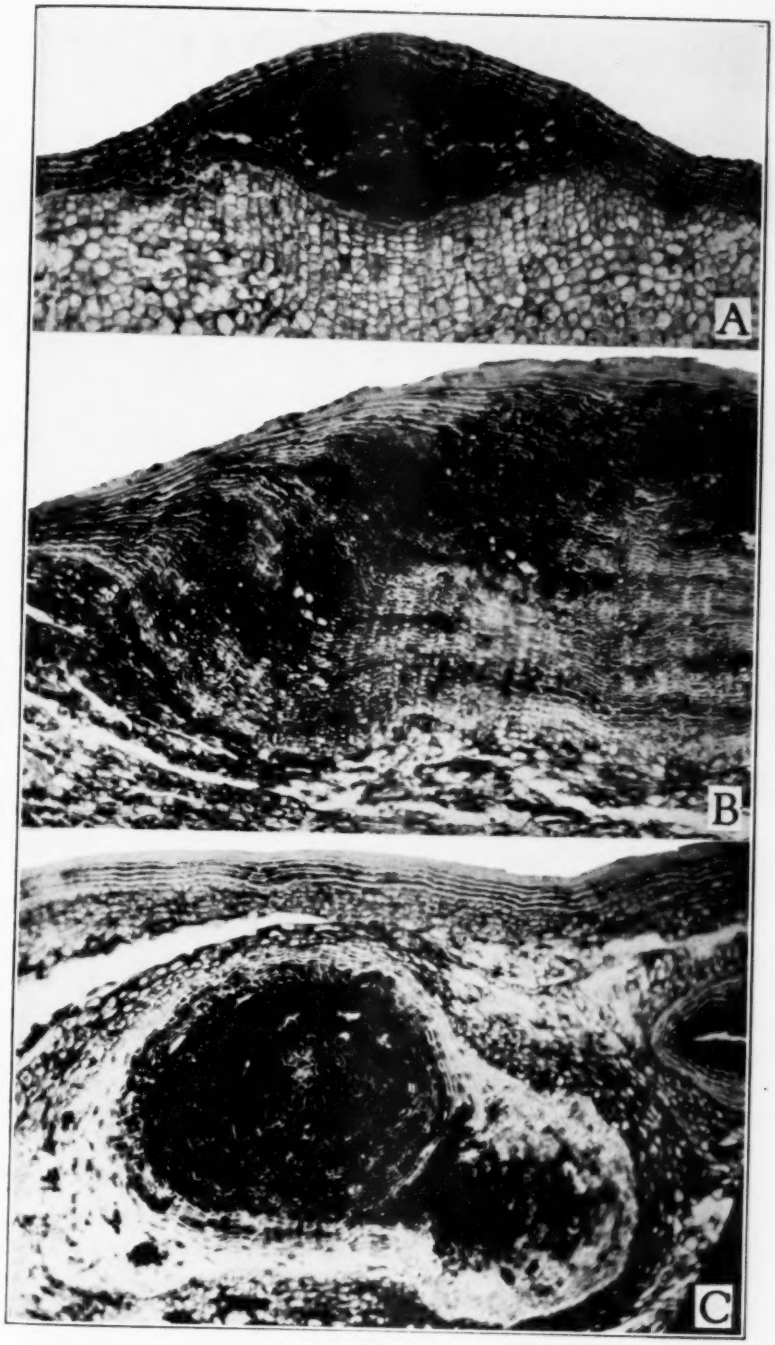

APPLE MEASLES

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APPLE MEASLES

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WHITE ROT OF ALLIUM IN EUROPE AND AMERICA

J. C. WALKER

WITH PLATE XXII

INTRODUCTION

The white rot (*Sclerotium cepivorum* Berk.) of onion and certain of its allies has been known in Europe since it was first described by Berkeley (1) in 1841. Its serious destructiveness to garlic in northern Italy was related by Voglino (8) in 1902, while its common occurrence in the British Isles was noted by Cotton and Owen (3) in 1920. A recent account by Caballero (2) describes it as of consequence upon the garlic crop in northeastern Spain. The first authentic report of this disease in America was from Oregon in 1918 and a second report came from Virginia in 1923. The fact that it has become established on our continent and that other infested areas will undoubtedly be located in the future makes it of special present interest to American phytopathologists.

DESCRIPTION AND HOST RANGE

White rot is known to affect onion (*Allium cepa*), Welsh onion (*Allium fistulosum*), leek (*Allium porrum*), garlic (*Allium sativum*), and shallot (*Allium ascalonicum*). It may attack the plant at any time during the growing period, provided external conditions are favorable; moreover, it is not uncommon for it to continue as a bulb rot following harvest. The first sign of the disease upon the growing plant appears as yellowing and dying back of the tissue, beginning at the tips of the leaves and progressing downward. The rate of this advance varies with the rapidity of the fungus attack, which in turn depends upon environment. A gradual decline of the plant may thus continue for some days or weeks, or in the case of young plants it may constitute a rapid wilt and collapse of aerial parts.

Coincident with the early symptoms of the disease above ground, further evidence is noted if the subterranean parts of the plant are examined. The fungus attacks both roots and bases of scales and is itself usually conspicuous by an abundance of superficial, white, fluffy mycelium. The roots are gradually destroyed and the fungus causes a semi-watery decay of the scales not unlike that caused by *Sclerotinia libertiana* on other vegetables. Rather early in the development, minute, black sclerotia are formed (See plate XXII,A). These are uniformly spherical, hard, and not over a half millimeter in diameter. They form either on the surface of or are imbedded within the decaying tissue. In any case they become readily detached as the decay progresses. In extreme cases the entire subterranean portion of

the plant may be almost completely destroyed, and the plant then offers no resistance to being pulled.

In case of late infection, the fungus also almost invariably invades at the base of the bulb and nearly full-grown bulbs may thus show early stages of the disease (See plate XXII, B). If such bulbs go into storage or transit, the decay continues.

The manner of attack and symptoms as described apply in general to all species affected; namely, to onion, garlic, leek, and shallot. No exhaustive study of the comparative resistance of species and strains has been made. Cotton and Owen (3) cite shallot and leek as more resistant than onion.

COMPARISON WITH CERTAIN OTHER DISEASES OF ONION

White rot has perhaps been most commonly confused with the Botrytis rots which affect onion bulbs following harvest. While the type of decay is somewhat similar, there are several easily distinguishable points of difference. The sclerotia of white rot, which are so abundant and constant except in the very early stages, are less than one millimeter in diameter and thus much smaller than those of any of the three forms of Botrytis which occur on onion. The latter most commonly invade through the neck of the bulb, while white rot almost invariably enters at the base. White rot usually makes its greatest advance before harvest, while the Botrytis neck rots rarely occur until after harvest.

A decay of garlic bulbs from Italy was noted by Mr. E. D. Eddy in New York City in 1919. From diseased specimens he isolated a species of yellow-spored Aspergillus. The latter has been referred to Dr. Charles Thom, U. S. Bureau of Chemistry, who is at present studying the group. Since he has not as yet published a description, it will be temporarily referred to by his number, *Aspergillus sp.* 4660. Inoculations by the writer showed this form to be an aggressive parasite of mature bulbs of both onion and garlic. It might be confused with white rot, inasmuch as the fungus forms sclerotia abundantly in pure culture and in decaying bulb tissue. They are to be distinguished from those of *Sclerotium cepivorum*, however, by the fact that they are somewhat lighter in color and average about double the size. Accompanying the production of sclerotia by *Aspergillus sp.* 4660, there is also commonly formed on the decaying tissue a yellow mold which consists of the conidia and conidiophores of the fungus.

Fusarium bulb-rot, which most commonly starts at the base of the bulb after mid-season, might be confused with the early stages of white rot, especially in its aerial symptoms. The greater abundance of superficial white mycelium on decayed tissue and the early appearance of sclerotia

are again the chief distinguishing characters of white rot. There is probably no likelihood of confusion by pathologists between white rot and other common diseases of the onion bulb. The aerial symptoms might at times be mistaken for those of mildew, but this should not prove troublesome because of the early appearance of diagnostic characters on the subterranean parts of the host plant.

THE CAUSAL ORGANISM

The organism was described originally by Berkeley (1) as a sterile fungus and named *Sclerotium cepivorum*. Voglino (8) studied the organism in detail and describes the production of sporodochia of hyaline conidiophores 40 to 50 μ in length, upon which are borne spherical, hyaline, catenulate conidia 3 to 4.5 μ in diameter. On the basis of his description he renamed the fungus *Sphacelia allii*. Later workers have not confirmed the description of the conidial form by Voglino, and though Cotton and Owen (3) noted the production of microspores, they never succeeded in bringing about their germination. The fungus exhibits several points of resemblance to Sclerotinia and further morphological study may lead to the discovery of a perfect stage or functional conidia.

It would appear, however, that in nature the fungus overwinters in the form of sclerotia. The sclerotia germinate readily under proper conditions of moisture and temperature, and the hyaline, branched mycelium grows rapidly as a saprophyte. It probably may live for long periods on dead refuse in the absence of the host. It is known to remain viable for several years in the soil without the presence of host plants.

Strains of the fungus were collected by the writer in 1922 from the British Isles, Holland, France, Spain, and Teneriffe. These all appear to resemble one another in general character but they are still being studied comparatively as to morphological and physiological details. Part of this study is being taken up by Prof. Whetzel, and since the results will be published at a later date, further discussion of the causal organism will be deferred.

DISTRIBUTION AND IMPORTANCE IN EUROPE

Previous reports of occurrence in England (1, 3), Italy (8), and Spain (2) have been cited. These were supplemented by a personal survey by the writer in a number of onion and garlic growing regions of Europe in 1922. In England the disease has been carefully surveyed by Cotton and Owen (3). They report its wide occurrence throughout the British Isles and regard it as of considerable economic significance. The disease appears in May or earlier on the spring-sown onion crop and is most destructive during June and early July. Few new infections occur during August and

most of the early infected plants have died by this time. In autumn onions are commonly sown in England for the spring bunching trade. Certain of these plantings were found by the writer to be severely affected with white rot in September. Leek also suffers from the disease during the cooler months. Growers in England have in large measure learned to avoid infested areas and the long persistence of the fungus in the soil is generally recognized.

In Holland the disease exists in the onion-growing sections in the islands of Zealand, but apparently not to so destructive a degree as in England. It is probable that judicious rotation in this intensive truck growing region has served to hold the disease in check. The disease is known in France (4) and no doubt at times is quite destructive. It was collected by the writer on both onion and leek in Brittany in June, but apparently was not a serious factor in the onion-growing section of that province. Sorauer (7) describes from Germany a disease caused by *Sclerotium cepivorum*, but from his discussion it seems more likely that he was referring to one of the Botrytis rots of the onion bulb.

In northern Italy, the disease is still one of consequence to the garlic crop, which is started in late fall or early winter. It is described by Voglino (8) as especially destructive in cool, wet, spring weather, and my observation at Turin in the latter part of May showed the disease in advanced stages. No report from central or southern Italy has been noted by the writer. In Spain garlic is started during the winter months and matures in mid-summer. It is grown commercially usually in the foothill regions, rather than at sea level. Intensive onion production is carried on in the much warmer coastal plains in the vicinity of Valencia and La Coruña. The onion seed is sown in beds from August to January and the seedlings are transplanted from February to April. The early crop matures in July, and the later and larger of the two crops, in August. White rot has been known as a destructive disease of garlic in the province of Cataluña, especially in the intensive section surrounding the small town of Bañolas, for twenty or more years. Personal observation in this section showed nearly every field to be more or less affected and in many fields in roughly circular areas one to several rods in diameter were found in which most or all the plants had been killed by May 15. The organism seems to be most destructive here, as in other cases noted, in the moderately cool part of the growing season. Search in both of the onion sections—Valencia and La Coruña—failed to reveal any evidence of white rot. It is either entirely absent or of minor importance in these sections. It is an interesting question as to whether these are cases of chance escape or whether the soil or environment are such as to prevent the establishment of the fungus as a destructive parasite.

The Canary Islands were visited in late June, just as the onion crop was being harvested. An occasional bulb was found decayed by *Sclerotium cepivorum*, indicating that early in the season it may have been even more destructive.

White rot may thus be considered a disease of widespread occurrence throughout western Europe. Under certain conditions it becomes a very destructive malady and one that may be looked upon with considerable concern by American onion growers. One is led to suspect that its introduction into any one of our intensive onion-growing sections, where continuous cropping with onions is so often the rule, would lead to its establishment as a destructive disease, provided environing conditions were favorable. From general observations in Europe it would appear to thrive best at moderately cool temperatures and with moderate soil moisture.

OCCURRENCE IN AMERICA

The references to *Sclerotium cepivorum* on onions in Ohio which were made by Selby (6) and by Humbert (5) are undoubtedly erroneous, since it is quite obvious from their description that they were dealing with one or more of the species of Botrytis which cause the neck-rot disease. The first authentic collection of the disease in America of which we have record was made in June, 1918, near La Grange, Oregon, by County Agent P. H. Spillman. The fungus was found on both garlic and multiplier onion. Specimens were sent first to Prof. H. P. Barss, at Corvallis, Oregon, who in turn forwarded them to Prof. H. H. Whetzel, at Cornell University, Ithaca, N. Y. The latter isolated the organism and diagnosed it as *Sclerotium cepivorum*, but made no published report. Within the past year this collection and culture have been compared by the writer with material obtained at various points in Europe and the identity of the American collection has been confirmed. No recurrence of the disease in Oregon had been reported up to 1923. In March, 1923, diseased specimens of multiplier onion were sent to the writer from a farm near Norfolk, Va., by Prof. Herbert Spencer. These were also found to be attacked by *Sclerotium cepivorum*. In the late autumn of 1923, Mr. R. J. Davis, Pathologist at the Norfolk Station, reported that on the same farm four acres of multiplier onions were severely damaged by the disease.

Our soil temperature and soil moisture studies (9), which will be reported in detail in another paper, indicate that the disease is most destructive at an average temperature of 15° to 18° C. and at medium soil moisture. The conditions under which our winter crops of shallot and onion are grown in the southern states would appear to be very favorable for the disease and simulate in a general way the conditions under which it is most destructive in Europe. The recurrence of the disease at Norfolk

in even more destructive form the second season supports this assumption. The existence of a favorable environment in the northern onion sections is not so certain. Except in the early part of the growing season the average soil temperature is probably somewhat higher than the optimum for the disease. We, of course, have yet to learn the effects of our northern winters upon the parasite.

MODES OF FURTHER INTRODUCTION AND DISSEMINATION

Enough has been said regarding the disease to imply that the principal means of wide dissemination of the fungus is the transportation of infected bulbs or plants, or by containers of the same. It is not likely that affected bulbs ever produce seed and there is still less probability that seed, except under unusual circumstances, becomes contaminated and thus constitutes a channel of distribution. We may therefore look to the trade practices which involve the transport of bulbs and seedlings as the chief means of introduction into new localities..

There are imported each year into the United States a million bushels or more of onion bulbs for food purposes from various countries in Europe and Africa. While the largest portion of this quantity comes from the Valencian district of Spain, which appears to be free from white rot, imports are commonly made during years of crop shortage from Holland, Belgium, France, Roumania, Italy, and Egypt. It is likely that some of such shipments come from infested areas and may carry more or less of the white-rot fungus. However, the probability of introduction and establishment of the parasite in our soils by this means is comparatively remote. Should bulbs of Allium be introduced for propagative purposes, the probability would be much greater, but such practice is subject to the provisions of the Plant Quarantine Act.

The quarantine against garlic bulbs for propagative purposes is not so easily applied, however. Several million pounds of garlic are annually imported to the United States from southern Europe, and undoubtedly some of them come from areas infested by *Sclerotium cepivorum*. Though they are ostensibly all imported for food purposes, there is nothing to prevent some of the bulbs being used for propagative purposes. This channel is, therefore, undoubtedly the one by which introduction of the disease into our soils from abroad is most likely.

Once established in a few localities in America the danger of rapid spread, as a result of practices of extensive distribution of seedlings and bottom sets of onion, is imminent. If conditions prove favorable for its development in one or more of our intensive bottom-set-growing sections, it is obvious that widespread distribution will soon follow. The rapidly increasing traffic in southern-grown onion seedlings for both southern and northern market gardens is an equally important channel.

SUMMARY

1. White rot is a disease of onion and related plants which is very destructive in certain parts of Europe. Its recent appearance in America is therefore of special interest to phytopathologists.

2. The disease is known to affect common onion, Welsh onion, leek, shallot, and garlic. The symptoms are described and compared with those diseases with which it is liable to be confused.

3. The causal organism (*Sclerotium cepivorum*) overwinters and persists indefinitely in the soil under European conditions. The fungus is sterile except for the production of microspores, germination of which has never been observed.

4. White rot is more or less common throughout western Europe; it is often seriously destructive to onion and leek in the British Isles and to garlic in Spain and Italy.

5. Two authentic reports of its occurrence in America have been recorded. It was noted on multiplier onion and on garlic in northeastern Oregon in 1918, but no recurrence has been observed in that locality. It was found on multiplier onion near Norfolk, Virginia, in March, 1923, and recurred in much larger proportion in the autumn of the same year.

6. Observation in Europe and laboratory experiments by the writer indicate the disease to be most destructive in a moderately cool soil (15° to 18° C.), having a medium moisture content. The conditions which prevail for the winter crop of onion, garlic, and shallot in our southern states seem to be most favorable for the disease. It remains to be determined whether the conditions under which our northern onion crop is grown offer a favorable environment.

7. The chief mode of widespread dissemination is on diseased bulbs or seedlings. Further introduction of the parasite into American soils is most likely by way of garlic bulbs imported for food purposes but occasionally diverted to use in propagation. With the large traffic in bottom-sets and seedlings of onion in this country there is great danger of widespread and rapid dissemination from original centers of infection.

OFFICE OF COTTON, TRUCK AND FORAGE CROP DISEASE INVESTIGATIONS,
BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

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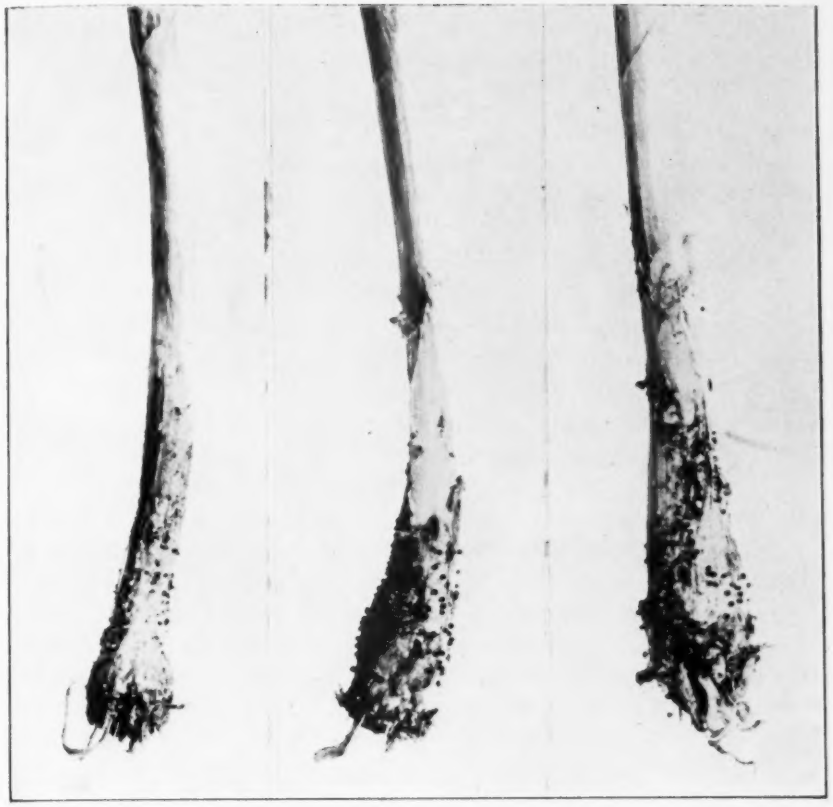
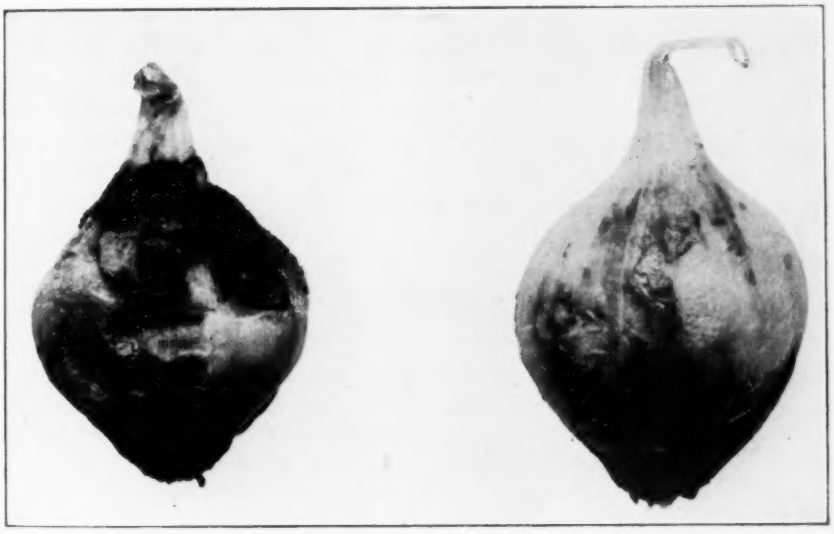
DESCRIPTION OF PLATE XXII

PLATE XXII, A. White Portugal onions produced from sets which were planted in soil thoroughly infested with *Sclerotium cepivorum*. Note that the fungus has completely destroyed the roots and is invading the scales. The disease has passed the early stage wherein the fluffy, white superficial mycelium of the fungus is so pronounced, but abundant spherical, hard, black sclerotia have formed characteristically on the decayed tissue. See further description of the disease in the text. (Enlarged $\times$ 2.)

B. Small white "pickle" onions affected with *Sclerotium cepivorum*. Specimens collected in market at Paris, France, in August, 1922. In this instance the plants were evidently attacked late in the growing season since the bulbs seemingly formed normally and the infection is confined to the outer scales. The disease is here assuming the rôle of a storage decay.





SCLEROTIUM CEPIVORUM

UNIV. OF MICH.

SCLEROTINIA INTERMEDIA N. SP. A CAUSE OF DECAY OF SALSIFY AND CARROTS

G. B. RAMSEY[1]

WITH PLATE XXIII AND SIX FIGURES IN THE TEXT

For the past four years the writer has been making a study of the transit and market diseases of vegetables on the Chicago market, with special reference to the decay caused by Sclerotinia species. During this time, a large number of cultures have been collected and studied, the results of which will be given in a subsequent paper. At the present time, attention is to be called to one strain which has been under observation since April 10, 1920, and which has characteristics that distinguish it from all other Sclerotinia species obtainable.

The original culture of this fungus was isolated from the roots of salsify (*Tragopogon porrifolius* L.). Decaying roots were found with a fine, rather appressed cottony mycelium covering slightly sunken, watery lesions which showed a pinkish discoloration around the border. Macroscopic observations indicated that this fungus belonged to the genus Sclerotinia, but it was not until the sclerotia began to form that obvious differences appeared which seemed to characterize it as distinct from other species isolated.

This fungus was again isolated from the roots of carrot in February, 1921, but since that date has not been found. Up to the present time over two thousand isolations of fungi from market produce have been made in the Market Pathology laboratory, and almost three hundred of these have been of the genus Sclerotinia. Judging from these data, it seems fair to conclude that the Sclerotinia sp. mentioned above is, so far, of minor importance or that it comes from more or less localized districts which do not ship much produce to the Chicago market.

Since 1920 this fungus has been carried in culture and compared with the cultural characteristics of all the Sclerotinia strains that could be found upon the market and all strains that could be obtained from fellow workers located at the various experiment stations and agricultural Colleges.

Sclerotinia cultures have been obtained from practically all important

[1] Contribution from the Research Laboratory on Market Diseases of Vegetables and Fruits; United States Department of Agriculture, Bureau of Plant Industry, and the Botany Department, University of Chicago cooperating.

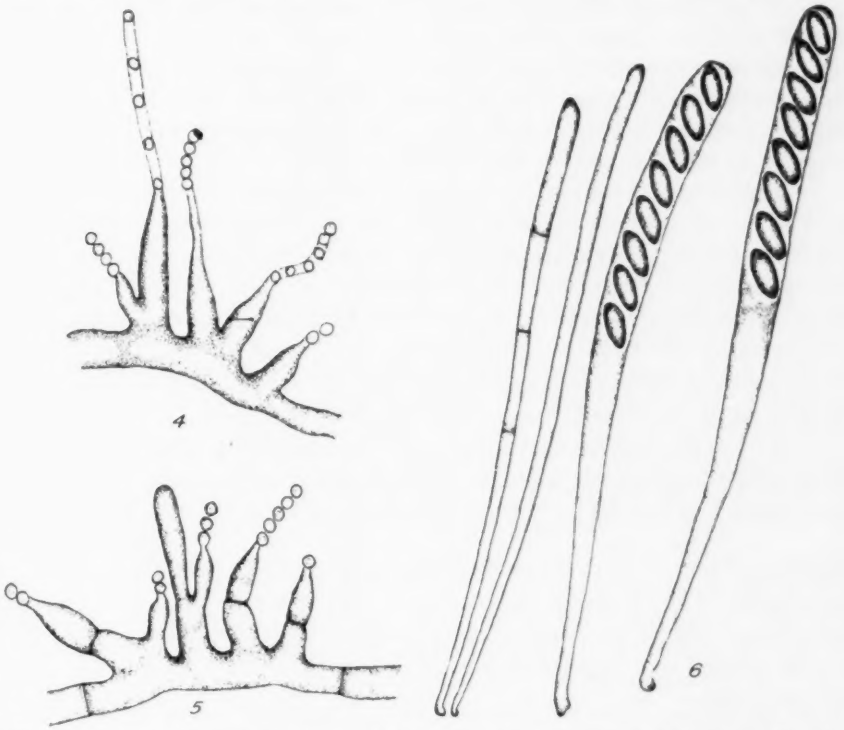
The writer wishes to express his thanks to Prof. H. H. Whetzel, of Cornell University, and Prof. Frank Dickson, of the University of British Columbia, for comparing this strain with the cultures of the genus Sclerotinia in their respective laboratories, and for helpful criticism in the preparation of this paper.

truck and market garden districts of the United States and the host range includes all of the economic vegetables that are subject to decay by Sclerotinia spp. No cultures have ever been found identical with the strain under consideration, and no description in the literature is applicable to this fungus. In view of the facts above mentioned, it seemed advisable to describe this fungus as a new species. Accordingly, the writer offers the following name and description.

Fig. 1. Unexpanded apothecia of **S. intermedia** as they appear when first coming through the sand in pot cultures. Fig. 2. Cluster of apothecia arising from sclerotia grown on corn meal moistened with prune juice in flask culture. Fig. 3. Stages in the development and expansion of the apothecia.

Sclerotinia intermedia n.sp. Apothecia funnel-shaped to discoid, one to several from a single sclerotium ranging from 2.5 to 6 mm. diameter, average 3.5 mm.; 7 to 12 mm. high, average 9 mm. Stipe cylindrical, 1 to

1.25 mm. diameter, attenuated downward. Disc tawny-olive[2] at first, changing to snuff brown at maturity, cinnamon buff after ejection of spores. Asci 8 spored, cylindrical to cylindro-clavate, 7.2 to 7.7 by 121.6 to 131.4 microns, average 7.5x127.0 microns. Ascospores elliptical to ovoid, unicellular, hyaline, 3.8-5.7x10.4-15.2 microns, average 4.9x12.7. Paraphyses filiform, simple. Microconidia globose, hyaline 3.8 microns diameter,



Figs. 4 and 5. Manner of microconidial formation on vegetative hyphae. Fig. 6. Asci and paraphyses of **S. intermedia.**

formed acrogenously on short, flask-shaped sterigmata; sometimes produced endogenously in liquid media. Sclerotia black, irregular, 1 to 3 mm. diameter, averaging 2.2 mm. often joining together in elongated chains. Mycelium fine, cottony, white to pale olive buff or cartridge buff colored, forming Roman green appressoria at contact with foreign bodies.

On roots of salsify (*Tragopogon porrifolius* L.) and carrot (*Daucus Carota* L.) on the Chicago market.

Sclerotinia intermedia differs from the almost ubiquitous *S. libertiana* in that the vegetative growth is less luxuriant and cottony, and that the

[2] Ridgway, Robert. Color standards and color nomenclature, Washington, D. C., 1912

mycelium is not always pure white, but often pale olive buff to cartridge buff in color. On standard nutrient media such as potato-dextrose, oatmeal and bean agar, the mycelium of *S. intermedia* is more scant, finer and appressed, and has more appressoria than *S. libertiana*. The sclerotia of the former are also much smaller and more numerous on the above mentioned media.

S. intermedia produces slightly more mycelium than *S. minor*, and the radiating hyphae form a more appressed compact layer. The sclerotia of *S. intermedia* are larger in diameter and are more fleshy in texture. They often have a tendency to form elongated chains made up of two to several sclerotia joined together end to end. In *S. minor* the sclerotia have a tendency to join together in crust-like formation.

In addition to the above mentioned growth characteristics and the differences in spore and asci measurements, the temperature reactions of *S. intermedia* are quite distinct. This difference is especially noticeable at temperatures just below and a few degrees above 0° C. At—.5 to 3° C. it grows about twice as fast on potato-dextrose agar, as either *S. minor* or *S. libertiana*. At temperatures around 7° C. each of the three named species grow at approximately the same rate, while at 20° C. *S. intermedia* develops at about one half the rate of the other species.

S. intermedia produces a watery, soft rot of all the ordinary truck crop plants that are commonly attacked by Sclerotinia. Inoculation experiments have shown this fungus pathogenic to the following hosts:

Asparagus shoots	Cucumber fruits	Pea pods
Bean pods	Lemon fruit	Sweet potato roots
Beet roots	Lettuce heads	Turnip roots
Carrot roots	Parsnip roots	Tomato fruit
Celery stalks		

Of the numerous inoculation tests conducted only the potato tuber has shown complete resistance to *S. intermedia*. The decay produced in all other host plants is quite comparable to that caused by the other species of Sclerotinia, and in most cases is indistinguishable, until a pale olive-buff color of the mycelium becomes noticeable or until sclerotial formation begins.

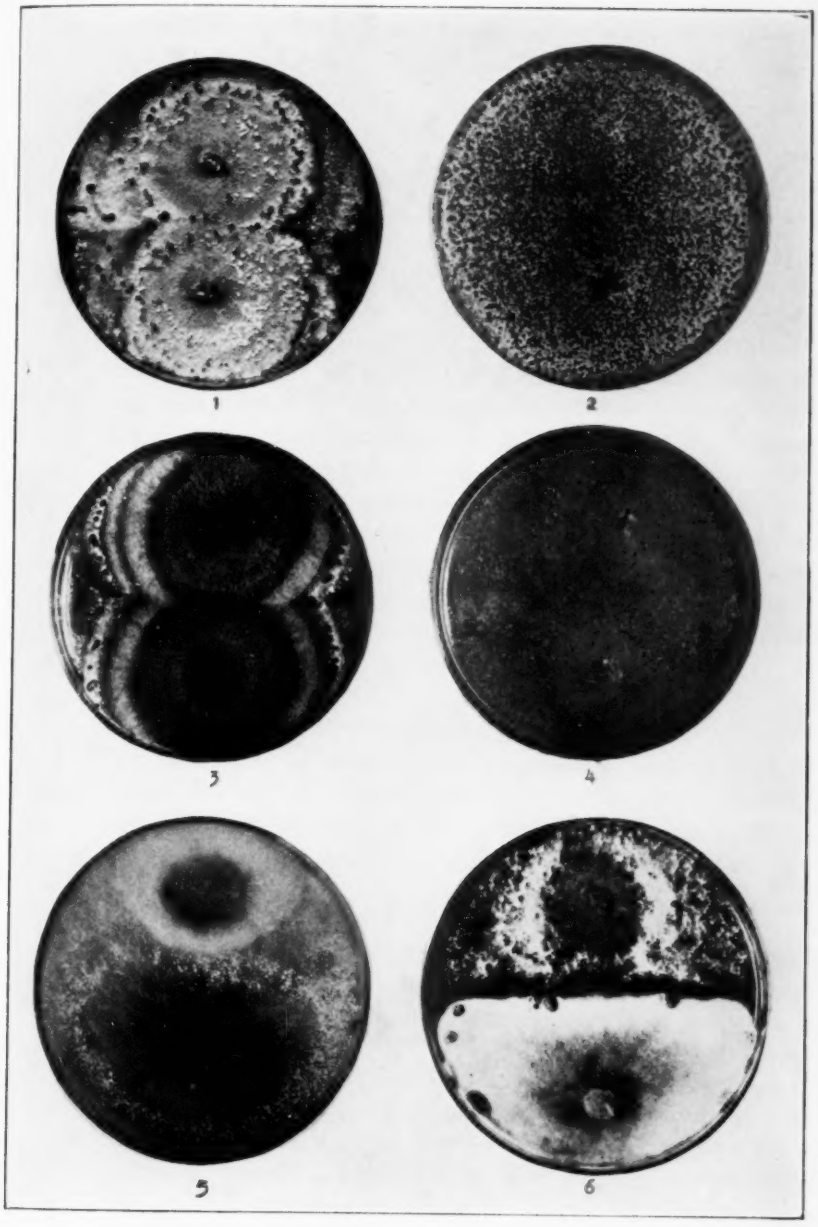
SUMMARY

1. A strain of Sclerotinia found on the Chicago market causing decay of the roots of salsify and carrots has shown morphological and physiological differences which distinguish it from all other species of the genus Sclerotinia.

2. The sclerotia formed upon most culture media are intermediate in size between those produced by *S. libertiana* and *S. minor* and an intermediate amount of mycelium is produced. Hence the descriptive name *S. intermedia* is proposed for this species.

DESCRIPTION OF PLATE XXIII

Fig. 1. **S. intermedia** on potato-dextrose agar. Fig. 2. *S. minor* on potato-dextrose agar. Fig. 3. **S. intermedia** on potato agar without dextrose. Fig. 4. *S. minor* on potato agar without dextrose. Fig. 5. Planting of **S. intermedia** (above) and *S. minor* (below) on the same plate of potato-dextrose agar and grown at room temperature. Note the difference in rate of growth and in the character and amount of mycelium and sclerotia formed by the two species. Fig. 6. **S. intermedia** (above) and *S. libertiana* (below) growing together on potato-dextrose agar at 5–7° C. showing equal rate of growth at this temperature.



SCLEROTINIA CULTURES

SPHAEROPSIS MALORUM AND MYXOSPORIUM CORTICOLA ON APPLE AND PEAR IN OREGON.

S. M. ZELLER

Stillinger[1] has already reported from Oregon on apple rot caused by a hyaline-spored fungus of the Macrophoma type which he believes does not produce apple canker. He was also unable to find either the brown spores of the Eu-sphaeropsis type or the Diplodia type, which are characteristic of *Sphaeropsis malorum* Berk., as it is found in the eastern part of the United States. For these reasons the writer and other Oregon pathologists have wondered whether perhaps the Oregon fungus might not differ materially from the true black rot organism as described by Hesler and others. The writer thought it worth while, therefore, to examine collections of apple and pear cankers which for several years have been accessioned with notes in the Department of Botany and Plant Pathology.

The writer feels that a few facts concerning these collections, and cultures from certain of them, are well worth while recording here to help clear up the situation with reference to *Sphaeropsis malorum* Berk. in Oregon, and incidentally a note concerning the limited occurrence of *Myxosporium corticola* Edg. in the state.

SPHAEROPSIS

Herewith in table 1 is presented the essential data of Oregon collections which may be referred to *Sphaeropsis malorum* Berk. without question. As far as already known, the fungus has been observed from the Hood River, Willamette and Umpqua Valleys in Oregon.

The fungus has usually been found as a bark canker, often on small branches, killing the bark and discoloring the wood to some depth, as in the case of other die-back organisms, often following slight sunscald or winter injury, and sometimes associated with *Nectria galligena* on loose dead bark over canker spots. The canker doubtless occurs endemic in the fruit growing districts of the Willamette and Hood River valleys, but is usually found in orchards which have been abandoned or in those which do not receive the usually-prescribed sequence of sprays suggested for the control of other fungous diseases. The black rot canker assumes its worst form when its infection is subsequent to other fungi, winter injury, sunscald, or die-back from various causes. Of itself *Sphaeropsis malorum*

[1] Stillinger, C. R. Apple black rot (*Sphaeropsis malorum* Berk.) in Oregon. Phytopathology **10**: 453–458. 1920. Literature cited, p. 458.

TABLE 1.—*Occurrence of Sphaeropsis malorum Berk. in Oregon.*

Date of Collection	Collector	Collection to be found in	Locality	Host	Form	Measurement of pycnospores in μ	Form of Spores to be found in collection
Feb. 21, 1911	F. D. Bailey	O.A.C. Plant Path. Dept. Acc. A80, Zeller Herb. 2504	Corvallis	Apple	Bark Canker	27–38 × 10–13	Hyaline and brown, 1-celled; brown, diploid
Oct. 23, 1911	H. L. Rees	Acc. B45	Hood River	Apple	Bark Canker	30–35 × 11–13	Hyaline and brown, 1-celled; brown, diploid
Feb. 27, 1912	H. L. Rees	Acc. B149	Corvallis	Apple	Bark Canker	28–34 × 12–16	Hyaline and brown, 1-celled; brown, diploid
April 3, 1912	H. L. Rees	Acc. B201b	Forest Grove	Apple	Bark Canker	24–32 × 10–12	Hyaline and brown, 1-celled; brown, diploid
April, 1912	H. L. Rees	Acc. B205b	Salem	Apple	Bark Canker	26–30 × 11–14	Hyaline, 1-celled; brown, diploid
Feb. 15, 1913	H. L. Rees	Acc. B113x	Corvallis	Apple	Bark Canker	22–32 × 10–14	Hyaline, 1-celled; brown, diploid
July 18, 1919	S. M. Zeller	A.O.C. Negative 19268	Roseburg	Apple	Bark Canker	25–32 × 10–12	Hyaline, 1-celled; brown, diploid
Aug. 14, 1919	S. M. Zeller	Zeller Herb. 1603	Salem	Apple	Leaf Spot		
Aug. 15, 1919	S. M. Zeller	Zeller Herb. 1579	Corvallis	Apple	Leaf Spot		
Aug. 28, 1920	S. H. van Trump	O.A.C. Plant Path. Dept. Acc. D661	Salem	Apple	Bark Canker	25–29 × 10–14	Hyaline, 1-celled; brown, diploid
Nov. 4, 1922	S. M. Zeller	Zeller Herb. 2374	Hood River	Apple	Leaf Spot		Primordial pycnidia
Jan. 4, 1923	F. M. Green	Zeller Culture 127	Hood River	Apple	Fruit Rot		
Feb. 20, 1923	V. W. Mason	Zeller Herb. 2493	Albany	Apple	Bark Canker	25–34 × 11–15	Hyaline, 1-celled; brown, diploid
March 1, 1923	V. W. Mason	Zeller Herb. 2496	Albany	Apple	Bark Canker	26–35 × 12–15	Hyaline and brown, 1-celled; brown, diploid
Feb. 27, 1912	H. L. Rees	Acc. B104	Salem	Pear	Bark Canker	21–25 × 7–10	Hyaline, 1-celled; brown, diploid

seems to cause merely a superficial cortex canker under Oregon climatic conditions.

The pycnidial form of fruiting on the bark evidently occurs more abundantly on apple than on pear and seldom matures further than the Macrophoma stage. After spores are discharged, however, and are lodged upon the bark surrounding the pycnidia, they become brownish and usually diploid. No true Diplodia has been found by the writer on apple or pear in Oregon. In fact, no other pycnidial forms have been seen on the same areas of dead bark occupied by pycnidia of *Sphaeropsis malorum*. Thus we feel safe in assuming that the colored spores are those from the Macrophoma type of pycnidia, since such diploid spores produce the Macrophoma with typical spores when cultured.

Black rot is endemic as a leaf-spot in Oregon. It is confined mostly to old or neglected orchards in sod, although an occasional outbreak in individual rochards is serious in some localities under favorable weather conditions. The unusually-few serious cases of leaf-spot in Oregon undoubtedly is due to the dry summer climate, there seldom being a rain after the leaves have opened until they have reached advanced maturation, or until just before leaf fall. Otherwise, with the casual organism as prevalent as it seems to be, there is no known reason why Pacific northwestern orchards should not suffer their share of damage from black rot leaf-spot.

The leaf-spot as it occurs here is the typical "frog-eye." Seldom, however, do pycnidia mature on the leaves. Black specks do frequently occur in the leaf-spots. When the epidermis is lifted away, these specks prove to be sclerotia (perhaps primordial pycnidia, mature specimens of which have not yet been observed). When these sclerotia are dissected out with a sterile needle and planted on agar slants they yield a mycelial growth typical of the black rot organism (compared with culture from Hesler). Apples have been inoculated from such cultures, which cause a black rot of the fruit, upon which pycnidia of the Macrophoma type described above have been produced.

Black rot of the fruit occurs rather frequently, as Stillinger has suggested. This, I believe, is most prevalent during the fall after early rains and, of course, would be most serious on the late picking varieties, such as Newton Pippin. No specimens of pear fruits decayed by this organism have been recorded.

The same growth in culture and the same type of rot of apple fruit has been obtained with fungous cultures secured from the three sources, i.e., leaf-spot, bark canker, and fruit rot. All of these cultures have given in return the typical pycnidia on inoculated apple fruit, and some on agar and sweet clover stems.

TABLE 2.—*Occurrence of bark canker caused by Myxosporium corticola Edg. in Oregon.*

Date Collected	Collector	Collection to be found in	Locality	Host	Measurement of spores in μ	Form of Conidia to be found in collection
Sept. 20, 1911	H. L. Rees	O.A.C. Plant Path. Dept. Acc. A 66D6	Corvallis	Pear	20–30 × 8–10	Hyaline, 1–3-septate before germinating
Oct. 11, 1911	H. L. Rees	Acc. A 100	Corvallis	Pear	24–25 × 11–12	Hyaline, 1-celled
Dec. 19, 1911	H. L. Rees	Acc. B 105	Salem	Pear	22–24 × 10–11	Hyaline, 1-celled
Dec. 22, 1911	H. L. Rees	Acc. B 105a	Salem	Pear	24–30 × 7.5–10	Hyaline, 1–3-celled, also ochraceous
April 3, 1912	H. L. Rees	Acc. B 201a	Forest Grove	Apple	18–22 × 10–12	Hyaline, 1-celled
Dec. 6, 1922	S. M. Zeller	Zeller Herb. 2628	Medford	Pear	22–28 × 7.5–11	Hyaline, 1–3-celled
Feb., 1923	S. M. Zeller	Zeller Herb. 2627	Corvallis	Pear	20–30 × 8–12	Hyaline, 1–3-celled
March 21, 1924	S. M. Zeller	Zeller Herb. 2648	Spring Brook	Apple	22–28 × 8–12	Hyaline, 1-celled

To summarize: There is no doubt that black rot of pomaceous fruits is wide-spread in Oregon—perhaps throughout the Pacific Northwest—but its economic importance is limited because of the dry summer climate. Its presence and identity have not previously been definitely reported because the development of the pycnidia spores is not usually maturated to the Sphaeropsis or diploid stages.

MYXOSPORIUM

Myxosporium corticola Edg. occurs in Oregon as a superficial bark canker. Its known distribution as indicated in the above table is limited to the Willamette and Rogue River Valleys, and it has been found more often on pear than apple. The infected areas of bark are typical of those described by Edgerton,[2] and Hesler and Whetzel[3] and others. The affected bark is sunken and browned under the epidermis, but not to the inner bark and cambium. The diseased bark dries and shrinks, leaving a marginal crack. On these sunken areas appear the acervuli, which often exude white or creamy, globular masses of spores. The spores are hyaline, measure 18–30x7.5–12 μ and are unicellular, becoming 1–3-septate and often yellowish before germination.

There is apparently no lasting or damaging effect on trees which have bark infections due to this fungus. There is apparently no decay of fruit due to this organism, at least such was not induced by artificial inoculation.

OREGON EXPERIMENT STATION,
CORVALLIS, OREGON.

[2] Edgerton, C. W. Two little known Myoxporiums. Ann. Myc. 6: 48–53. *2 fig.* 1908.
[3] Hesler, L. R., and H. H. Whetzel. Manual of fruit diseases, pp. 130–132. 1917.

MORPHOLOGICAL STUDIES ON THE INJURY TO APPLE CAUSED BY CERESA BUBALIS

J. C. Goodwin and F. A. Fenton[1]

With Four Figures in the Text

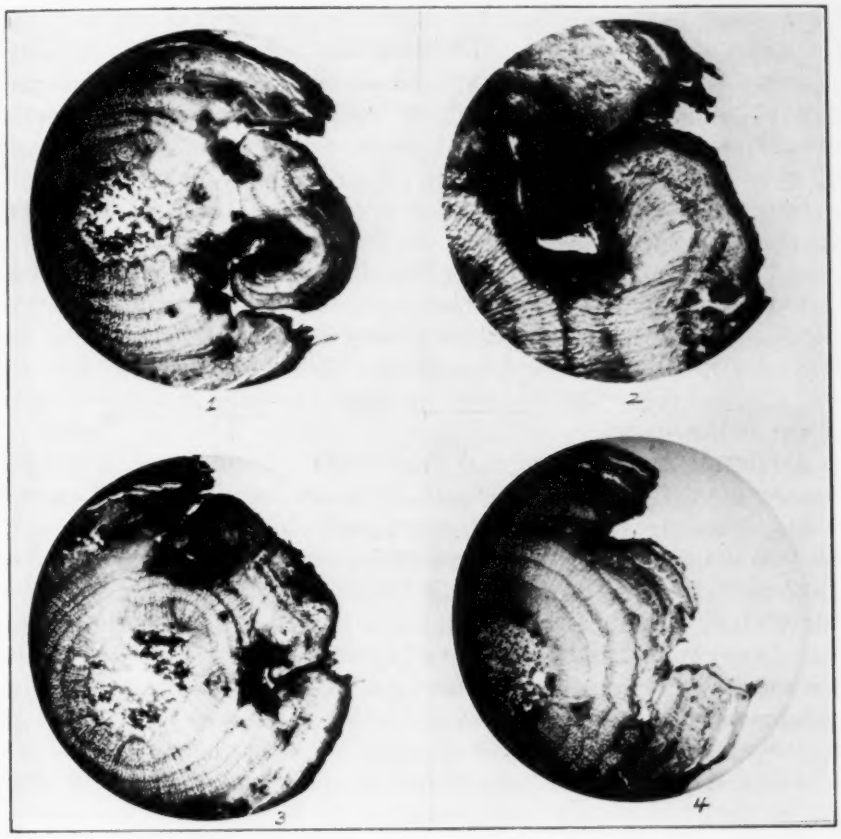
The peculiar lesions caused by oviposition of *Ceresa bubalis*[2] Fab. in woody plants are familiar to many entomologists. A histological study of these scars was taken up to determine the pathological changes in the plant tissues that take place following the incision of the sharp ovipositor of the female insect. At first cross sections were made from plum, pear and apple wood. Microscopical examination of slide material prepared from these revealed the character of the injury, and this was found to be practically the same for all. Therefore, the following notes are largely based on a study of the malformations produced on apple as a result of egg deposition by this species.

Fresh twigs were secured showing typical injury and cross sections 18 microns thick were cut through the lesions with a sliding microtome. This material was stored in 90 per cent alcohol until needed. The sections were stained in safranin from three to four minutes and were then washed, first in distilled water, and later in 95 per cent alcohol. This process removed practically all of the color from the cells with the exception of the vascular bundles. The wood was then dehydrated and counterstained in a weak hematoxylin solution for three to four minutes. After rinsing to remove an excess of this color, the ground tissue showed a deep blue in contrast to which the red vascular bundles could be easily identified. Permanent balsam mounts were made after dehydration and clearing in clove followed by cedar oil.

Sections through typical one-year old lesions (Fig. 1) showed that the injury was much more severe than apparent from the outside. The sharp ovipositor of the female is inserted through the cambium layer and deep into the woody fibre. These cuts often penetrate almost to the center of small branches. Directly after oviposition there is formed over that part of the wood thus exposed to the air, a corky layer of cells. The two strands of corky bark adjacent to each other on both sides of the incisions do not unite (Fig. 2). Because of this, a wedge-shaped section of the wood becomes separated from the remainder. That part of the cambium layer within the slits is isolated from the rest and the wound fails to heal over. The severed part of this, as well as the rest, continues to grow and the force exerted between these two results in the malformations of the tissue as illustrated. Often the cambium and adjacent tissues grow to about five

[1] Contribution from the Dept. of Zoology, Iowa State College.
[2] Order *Homoptera*; family Membracidae.

times their size at the time of oviposition. As a result of this abnormal growth of the tissue within the wedge and also because of the pressure exerted against this by the cambium around it, this part is gradually pushed outwards. At the same time the scar increases in size. As this process continues from year to year (Figs. 3 and 4) more and more of the wood between the cuts becomes corked over and sloughs off. Finally, at the end of the fourth or fifth year, the scar has increased considerably in



INJURY TO APPLE CAUSED BY CERESA BUBALIS FAB.

Fig. 1. Cross section through typical one-year-old lesion in apple wood caused by oviposition of *Ceresa bubalis* Fab. Fig. 2. Enlarged view of portion of lesion showing the two corky layers of newly formed bark. Fig. 3. Cross sections through two-year-old lesion. Fig. 4. Cross sections through three-year-old lesion.

width but there has been a corresponding decrease in depth. Altogether, mechanical injury is very severe and there are evidences that decay often sets in due to these wounds. While these may eventually heal over, the organisms have already entered the heart wood and ultimately this secondary injury may kill the entire limb.

THE SELF PRUNING OF WESTERN YELLOW PINE

W. H. Long

In our native forests of western yellow pine the individual trees, as they grow older, gradually lose their lower branches. This is also true of all forests in general. This dying of the lower branches without any apparent specific cause has been termed "self pruning" by foresters and scientists. The cause of this so-called self-pruning has usually been attributed to shading. As the tree grows the upper branches spread out in all directions toward the light, gradually cutting off the bulk of the sunlight from the lower and smaller branches. These lower branches gradually die and finally fall off.

For several years the dying of the lower limbs on trees of western yellow pine has been under observation. At the beginning of the study it was noticed that many dead and dying branches were present on young trees where shading could not have been the cause since the dead branches were in such positions on the tree that they would receive a large amount of sunlight. An examination showed that the branches of hundreds of yellow pine trees had died even when they were not shaded sufficiently to prevent their growth and development.

A careful examination of such trees showed the presence on the dead branches of the fruiting bodies of a fungus known technically as *Cenangium abietis*. The fungus starts on the lower branches near the ground where the moisture is the greatest, it then gradually works up the young tree year after year until a distance of 20 or 30 feet is reached. It rarely goes higher than 30 feet, due, apparently, to the lack of sufficient moisture that high from the ground. The fungus grows in the living bark and usually starts in a small side or terminal twig, and gradually works back to the larger branches which are finally girdled and killed. Branches of all sizes up to two inches in diameter are attacked and killed. The fungus does not seem to be an active virulent parasite since it attacks branches which are weakened by drouth, shade, etc., however, nearly all of our yellow pine areas are more or less subject to drouth at intermittent periods, and every year our open yellow pine stands are subject to climatic conditions which approach semi-drouths. These weakened branches, if low enough on the tree to be within the range of sufficient moisture for the germination of the fungus and its penetration into the tissues of the tree, are usually attacked and finally killed by the fungus. Such branches, especially, would usually recover after the period of drouth and continue to grow if the fungus did not attack them.

The fruiting bodies of *Cenangium abietis* appear as small black pustules, breaking through the bark on branches which have been dead for several months. These pustules ripen and discharge their spores during the rainy season. It is probable that at this time the new infections occur. A branch attacked by this fungus will have pale yellowish leaves, a dead twig here and there, and a generally unhealthy appearance. A close examination of the bark will show many dead resinous areas on the main branch. These areas finally coalesce thereby girdling and killing the entire branch. Of course, in dense stands shading may be a prominent factor in the self-pruning of the trees but it may also be only secondary since such dense stands are very favorable to the development of the pruning fungus, due to the shade prolonging the moisture conditions necessary to the growth of the fungus.

In many sections of New Mexico and Arizona this pruning fungus is very common and seems to be the usual cause of the self-pruning of the young trees. The semi-parasitic nature of this fungus prevents it from attacking, as a rule, vigorous and rapidly growing reproduction. It seems to limit itself to the lower, older and weakened branches. This early pruning of the branches of young timber is beneficial since more clear lumber will be obtained from such trees when they mature. It is a well known fact that knots, especially large ones, produce lumber of an inferior grade and hence lumber which will not sell for as high a price as that which is free from large knots. All of the lumber used for finishing the interior of our houses and homes must be free of knots and is known to the lumberman as select or clear lumber. Such lumber brings, on the retail market, about three times as much as the lower grades with their many knots. The clear lumber is obtained from the outer portions of the logs which usually come from close to the butt of the trees. All of the new wood added to the bole of the tree, after all of its branches are shed, makes clear lumber since the presence of branches is what produces knots. The earlier, in the life of a tree, that its lower branches are shed, the sooner will clear lumber be produced on that portion of the tree, hence any factor or agency which causes the early pruning of the lower branches on trees is beneficial to the lumberman. It is for this reason that *Cenangium abietis*, the pruning fungus of western yellow pine, is to be considered a valuable asset to our lumbering interests.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
ALBUQUERQUE, NEW MEXICO.

THE MICROLOOP. A RAPID METHOD FOR ISOLATING SINGLE SPORES.

MARIN S. DUNN

WITH ONE FIGURE IN THE TEXT

Recently while working on *Sclerotinia cinerea* under the direction of Dr. Charles H. Arndt, it became necessary to obtain pure cultures which were the result of single spore inoculations. Several methods were tried but all of them were very tedious. Therefore, attempts to develop a simpler and more rapid method were made. The procedure described in this paper is the outcome of these efforts, and it has been found to be quite satisfactory for the following reasons:

1. Single spores and particular single spores, if not too small, may be obtained rapidly by an easily-made "microloop" of glass.
2. The binocular dissecting microscope at times may be used with ease in the isolation of the spore.
3. Inconvenient cooling and heating agents are not required.
4. Mechanical injury to the spore is avoided.
5. The study of physiological strains is greatly facilitated.

The culture medium to be inoculated (in the form of agar slants or Petri dishes) is placed in a convenient position under a glass plate supported above a laboratory table at such a distance from the table-top that the investigator may manipulate a microscope under it without touching the plate with the head. A Bunsen burner is lighted under the plate about one-half hour before the inoculation is started, and the table-top is wiped with some suitable reagent. An inoculation room may be used instead of the glass plate.

The spores of the species of Sclerotinia studied are large enough (a little over 10 μ) to be seen clearly under the high power of a binocular dissecting microscope. For more accurate study, a compound microscope with a 16 mm. objective is placed by the side of the dissecting microscope under the plate. A tube of distilled water which has been previously sterilized is put into a convenient position. When necessary, instead of the water, the filtered, sterilized culture medium without agar may be used. In the case of *Sclerotinia cinerea*, the writer first studied the spores under the compound microscope, and later selected those desired under the binocular dissecting microscope.

A large drop of the medium is placed upon one end of a properly-sterilized and flamed clean glass slide. Into this drop, spores from the culture are introduced by means of a sterilized platinum loop, and gently

agitated. Two or three other drops of the water are placed side by side on the same slide. A loopful of drop No. 1 containing the spores is introduced into drop No. 2, a loopful of drop No. 2 into drop No. 3, etc., until satisfactory dilution is obtained. By observing the dilution at different times under the 16 mm. objective, it is possible to find a drop containing a few well-separated spores. Any other satisfactory method of dilution may be used.

The slide is then removed to the dissecting microscope, and the upper surface of the selected drop brought into view. Instead of using a capillary tube to suck up the spore desired, the writer uses what he terms a micro-

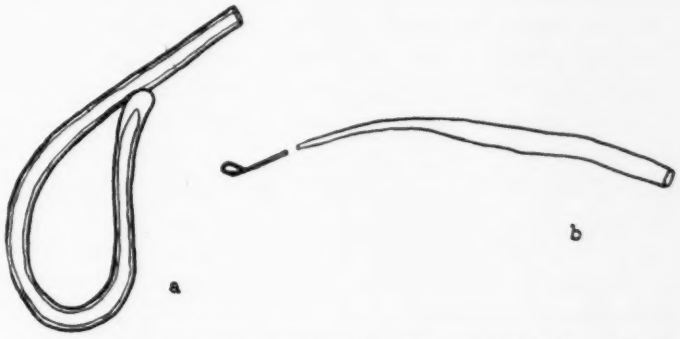


FIG. 1. a, the loop end of one type of microloop, approximately × 37; b, the same microloop showing the general structure and relation of its parts, the loop somewhat magnified.

loop. This is simply a piece of glass rod or glass tubing of small diameter drawn out into a delicate filament at one end, this end being bent to form a minute, flat loop (Fig. 1). If it is made from glass tubing, care must be taken that the central canal of the tube is closed in the loop end. The microloops may be of various sizes and shapes to fit the needs of the investigator. The writer used the one shown in the illustration for his isolation of the spores of *Sclerotinia cinerea*. This loop was approximately 1 1/10 mm. long and ½ mm. wide at its widest part (inside measurement).

It is possible to place the loop immediately over the spore in question so that it appears directly under the center of the loop. By gently lowering the hand until the loop almost touches the liquid around the spore, it is extremely easy to give a slight sudden up and down movement, rapidly touching the loop to the medium, and withdrawing it before any currents may carry other spores to it. As the loop is lifted from the liquid, there is carried with it a small drop of the medium in which, near its center, is held the desired spore. The tube of the microscope is then raised and the drop studied at leisure while held in the loop. When desired, the drop may

be transferred to a sterilized slide and studied under the higher magnification of the other microscope.

However, the writer finds in his work on Sclerotinia that it is often sufficient after studying the drop under the dissecting microscope to convey it to an agar slant. The spore is readily removed by simply allowing the drop contained in the loop to touch the surface of the agar. There is no injury due to mechanical handling. The rapidity and accuracy of isolation soon improve as the investigator becomes accustomed to the microloop employed.

It is a great advantage to select spores that are floating on the top of the drop on the glass slide rather than trying to obtain those below the surface. It may be found helpful to bend the glass filament so that the loop is in a plane slightly below the handle. This obviates the possibility that the handle may strike the surface of the medium. After using, the microloop is sterilized in any appropriate manner and reused as often as may be necessary.

If the spore is so small that the use of the dissecting microscope is impossible, it may be found convenient to attach the microloop in place of the capillary tube in a device like the one described by Roberts,[1] and work directly under the 16 mm. objective of the compound microscope, using a microloop of appropriate size.

Although the writer has not reviewed all the literature concerning single spore isolation, he feels since he has had such good results in such a surprisingly easy manner that he is justified in setting forth the method used for the benefit of those who may need an accurate and rapid technique.

BOTANICAL LABORATORIES,
UNIVERSITY OF PENNSYLVANIA.

[1] Roberts, J. W. A method of isolating selected single spores. Phytopathology 13: 558–560. *1 fig.* 1923.

PHYTOPATHOLOGICAL NOTES

Supplement to Handbook of the Plant Diseases in Japan. Vol. 1, pages 1–398, 1923, by Arata Ideta. This is an attractively gotten up book printed on thin, rough-surfaced paper. Unfortunately from our viewpoint it is printed in Japanese except some citations and names of parasites. Except for some half-tone illustrations, evidently copied from other publications, the illustrations are very good. American bookmakers might well copy the example set by this one and make the use of their books a pleasure instead of a task because of excessive weight, as a result of the use of shiny, heavily calendared paper of low actual grade and length of life. This volume evidently presents the additions to Japanese plant diseases in the groups: Myxomycetes, Bacteria, Oomycetes, Zygomycetes and Ascomycetes. A second volume is to give additions to the remaining groups.

Ideta's Handbook of the Plant Diseases of Japan, issued 1909–11, is fairly well known to American pathologists although printed in Japanese. In a personal letter Ideta states: "The first volume of the Supplement was published in Tokyo last April. But by the great earthquake catastrophe of September first, all copies of the Supplement which were preserved in the bookstore, the Shokabo, Tokyo, were burnt and now only a few copies remain in my hands. The eighth edition of my Handbook was published last May in Tokyo but all copies were burnt also at the same time. . . . . The Supplement is to consist of two volumes but I am sorry that it is impossible to publish the second volume in the near future." His address is Arata Ideta, Director of Ogori Agricultural School, Yamaguchi-ken, Japan. —PERLEY SPAULDING.

A Native Weed Host for Bacterial Blight of Bean. Angular, translucent, watersoaked spots were found upon the young leaves of trailing wild bean (*Strophostyles helvola* (L.) Britton) on September 25, 1923, in experimental plots planted by Dr. E. B. Mains at Purdue University Agricultural Experiment Station, LaFayette, Ind. These leaf lesions proved to be full of bacteria and from them a yellow organism was isolated which in culture closely resembled *Bacterium phaseoli* E. F. S. In the greenhouse in March, nine potted garden bean plants were sprayed with a water suspension of a 24-hour culture of the Strophostyles organism and typical, greasy, parchment-like, bacterial blight lesions were obtained on seven of the plants. At the same time two potted Strophostyles plants were similarly inoculated with a culture of *Bacterium phaseoli* isolated from garden beans and infection occurred on both plants. The lesions on Strophostyles remained smaller than those on garden bean. Reisolations from both host species yielded similar yellow colonies of *Bact. phaseoli.* Therefore *Strophostyles helvola*, a widely distributed native wild plant and in some places a common weed, may function as a host for bean bacterial blight, and should be considered undesirable in the vicinity of cultivated beans.—MAX W. GARDNER.

A Laboratory Convenience.—Many plant pathologists use culture media in connection with certain phases of their work, and are familiar with the inconvenience caused when the cotton plug becomes stuck to the inside of a test tube by a drop of the medium. An occasional drop of medium on the tip of the tubing apparatus is likely to come in contact with the inside of a test tube, near its mouth, unless one is very skillful in the tubing of media. The sketch submitted with this note shows a type of tubing apparatus outlet which has been used in the Plant Pathology Laboratory at the West Virginia Agricultural Experiment Station, for nearly fifteen years. These little double tubes have been found very convenient, and have been reported as quite helpful by men in other departments, where they have been tried. This article is written at the suggestion of some of these users.

The author wishes it clearly understood that he did not design the tube. The first tube of that type used in our laboratory was found in a lot of old, miscellaneous glassware, and was put to use as a tip for our culture media tubing equipment. What it was originally designed for, and what its name may have been, is quite unknown to the writer. No effort has been made to

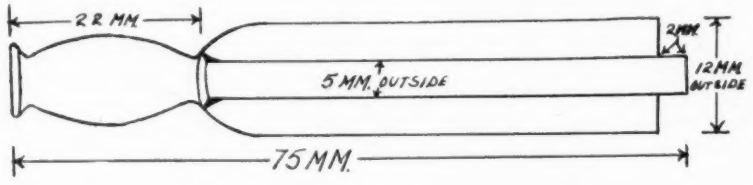


FIG. 1. Outlet for culture medium test tube filler.

learn whether there has been previous publication concerning this bit of glassware.

The tubes which we are now using were made by Eimer and Amend, as a special order. They are not listed in any catalog that has come to our attention.

The upper portion of the tube is single, and with an enlargement to make it hold rubber tubing better. The lower part of the tube is double, and the medium is delivered from the central tube. Even thick culture media, like oat meal agar, pass readily through the small tube, if tubed while hot. The outer tube fits inside any ordinary test tube and helps to keep the medium from contact with the upper part of the test tube. The inner tube should project about two millimeters beyond the outer tube in order to prevent the culture medium from coming in contact with the latter. It has been suggested that making the inner tube about four or five millimeters shorter than the outer tube would also be effective. This has not been tried in our laboratory, but would appear to be less desirable especially with thick media.—N. J. GIDDINGS.

Personals. Dr. H. W. Wollenweber of Berlin, formerly a pathologist in the Bureau of Plant Industry, Washington, D. C., came to this country about the first of June to take part in a conference on Fusarium diseases of plants, to be held at Madison, Wis., in June. He stopped in Washington for a few days en route to Madison. Other workers who will participate in this conference are Dr. Otto Reinking, pathologist for the United Fruit Company, Dr. C. D. Sherbakoff of the University of Tennesee, Miss Helen Johann of the Office of Cereal Investigations, Mrs. Alice Bailey of Chicago, and possibly others.

Dr. H. L. van de Sande-Bakhuijzen, a Dutch botanist, stopped in Washington, on his way to California a few days ago and spent a short time in the pathological offices of the Bureau of Plant Industry.

Dr. John R. Johnston, formerly of Washington and now pathologist for the United Fruit Company of Boston, was a recent visitor in Washington.

Dr. R. D. Rands has been transferred from the Office of Crop Acclimatization and Adaptation Investigations to the Office of Sugar Plant Investigations, and will work on sugar cane mosaic.

Dr. G. H. Godfrey has resigned his position in the Bureau of Plant Industry, Washington, D. C., effective May 31, having accepted the position of pathologist for the Bayer Company of New York City, manufacturers of the Uspulun products.

Dr. J. C. Walker came to Washington the last week in April for conferences relative to his work on onion and cabbage diseases and to give a talk at the meeting of the National Academy of Sciences on the results to date from the studies on the nature of disease resistance in the onion.

Mr. M. Shapovalov spent the latter part of February on a trip to the West Coast of Mexico for the purpose of studying tomato diseases, particularly western yellow blight.

Miss Minnie W. Taylor, Junior Pathologist in the Office of Investigations in Forest Pathology, Bureau of Plant Industry, U. S. Department of Agriculture, resigned on February 1, 1924, to assume the position of Librarian of the Museum of Natural History at Cleveland, Ohio.

ABSTRACTS OF PAPERS PRESENTED AT THE FIFTH ANNUAL MEETING OF THE CANADIAN DIVISION OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, QUEENS UNIVERSITY, KINGSTON, ONTARIO, DECEMBER 20, 21, 1923

Chestnut blight in Ontario. R. E. STONE.

Chestnut blight due to *Endothia parasitica* (Murr.) Ands. & Ands. has made its appearance in Ontario. Many trees in the Niagara Peninsula, near Font Hill, are badly diseased and the disease is spreading. The disease is also present in Norfolk county, near Simcoe. In the last named county twenty-five per cent of the trees are reported diseased. It is probable that the disease will not be checked until all the chestnut timber is gone.

Coryneum twig blight of Manitoba maple. J. E. HOWITT.

The Manitoba maples in the vicinity of the Ontario Agricultural College have many blighted twigs. In May, 1923, Mr. Hurst collected a number of specimens of blighted twigs all affected by the fungus *Coryneum negundinis* B. & C. This fungus is evidently the cause of the blight.

Some problems in forest pathology. A. W. MCCALLUM.

A distinction is made between the terms "forest pathology" and "forest mycology," the former being defined as that branch of the science of forestry which is concerned with the study of tree diseases, their causes and their control. Balsam fir grown for pulpwood can be managed on a short rotation and is subject to attack by many fungi. Further, in recent years it has come to be almost as highly regarded as spruce for pulpwood. For these reasons operators desire all available information as to the pathology of this species.

The first step is the identification of the various fungi which cause decay in living trees. This work, though uncompleted, has shown that erroneous ideas have been held as to the etiology of decay in balsam. A large number of trees have been analyzed for decay and from these figures it will be possible to secure data indicating the age to which the stand may be left to grow without risk of serious loss from decay resulting.

The pathological anatomy of tissue produced in Abies balsamea following an attack of the spruce budworm. C. H. MCLEOD.

Young shoots of *Abies balsamea*, when attacked by the spruce or balsam budworm, redden and often die. Structural disturbances initiated by the budworms may extend as far as the cambium is affected. The decrease in size of the growth rings is the only change noted macroscopically. There is no brownish zone as in frost injury.

Destruction of the leaves by budworms results in characteristic disturbances of the tissues of the growth rings formed during and immediately following the years of attack. Abnormal tissues vary greatly according to severity of attack and more than one type of abnormal tissue may be found in one section. Abnormal structures are—resin cells or canals, often in a complete ring; broadened or proliferated medullary rays; enlarged tracheids, large cells of parenchyma between medullary rays; groups of large parenchyma cells among tracheids, and parenchyma tracheids.

These abnormalities may appear in any part of the growth ring and all types may appear in the same ring.

A bakery infection with Monilia sitophila. GUILFORD B. REED.

Bread produced from a small bakery in Eastern Ontario when kept for four to five days developed a deep shell pink color through the loaf. The color increased until the loaf was 8 to 10 days old. An infection with the pigmented *Monilia sitophila* proved to be the cause. Spores were widespread in the bakery as a result of the practice of breaking infected loaves. Destruction of all infected material followed by cleaning and liberal application of Javelle water cleared up the trouble.

Mosaic studies IV. B. T. DICKSON.

(a) Mosaic of *Pisum sativum,* transmitted through seed, was again evident in Prussian Blue, Golden Vine, Canadian Beauty, Chancellor and White Marrowfat varieties at MacDonald College.

(b) Soy bean mosaic was found for the first time in Quebec.

(c) One case of transmission of tomato mosaic to healthy tomato under cage conditions by the flea beetle (*Epitrix cucumeris*) occurred in July, 1923.

A single case of transmission from *Physalis sp.* to *Browallia sp.* occurred in the author's garden but under uncontrolled conditions.

Experiments in oat smut control in 1923. J. E. HOWITT and R. E. STONE.

Experiments were conducted in co-operation with the Crop Protection Institute of the United States. All experiments were in triplicate on 1/40th acre plots.

Results of experiments are shown in the following table.

Treatment	Germination		Amount of smut	Yield per acre
	In Soil	In Zurich Germinators		
Formaldehyde sprinke	46	26	Trace	36.94
Formaldehyde spray	98	91	Trace	46.03
Copper carbonate dust, 2 ounces per bushel	97	95.5	1.2	44.86
Copper sulphate and lime dust	94	85.5	3.1	44.61
Copper sulphate dip	88	89	.73	45.89
Check	98	94.5	4.4	44.49

Summary

First—The formaldehyde sprinkle treatment reduced both germination and yield.

Second—The formaldehyde spray almost entirely prevented smut and gave the largest yield of any of the methods.

Third—Neither copper carbonate dust or copper sulphate lime dust were effective in eliminating smut.

Fourth—Copper sulphate dip reduced germination slightly but was effective in the control of smut.

Report of plant disease survey for Canada, 1923. F. L. DRAYTON.

The report covers more or less fully 260 diseases, with reports from 62 collaborators. A brief summary of the prevalence of some diseases of interest:—

Wheat stem rust: caused greater losses than in any year since 1916. In Alberta it was severe but too late to do serious damage. In Saskatchewan, much damage occurred to late crops. In Manitoba losses were estimated at 35,000,000 bushels. In the Eastern

Provinces severe infections occurred locally but losses were not as severe as in the Prairie Provinces.

Clover powdery mildew: widespread, loss is questionable except where clover is grown for seed.

Clover anthracnose (*Gloeosporium caulivorum*): caused the destruction of certain plots at the Central Experimental Farm.

Sclerotinia wilt or drop of sunflowers is widespread and is assuming alarming proportions in parts of Manitoba and Prince Edward Island.

Raspberry mosaic: serious in Manitoba, Ontario, New Brunswick, Prince Edward Island. Becoming common in Quebec and Nova Scotia.

Onion smut: occurs in Winnepeg, Manitoba; Leamington, Ontario; and Island of Montreal, Quebec.

Tobacco mosaic and root-rot: common in Ontario and Quebec.

White Pine Blister Rust occurs as follows:—

On Pines: British Columbia, Ontario, Nova Scotia, New Brunswick and Quebec.

On Ribes: British Columbia, Ontario, Nova Scotia, New Brunswick, Prince Edward Island and Quebec.

Seed treatment for smut control. W. P. FRASER and P. M. SIMMONDS.

This paper describes experiments on smut control with wheat and hull-less oats in co-operation with four of the Dominion Experimental Farms in Saskatchewan and Alberta. Copper carbonate, a mixture of equal parts of copper sulphate and calcium carbonate and sulphur in the form of dusts were used, also solutions of formaldehyde, semesan and chlorophol. All the substances gave good control except sulphur at some stations. Copper carbonate dust was most satisfactory for hull-less oats. The yields were not significant.

"Take-all" of wheat in Western Canada. W. P. FRASER.

Last season a field of Marquis wheat in northern Saskatchewan was found to be rather severely attacked by foot-rot. The field showed many areas of stunted grain with white heads characteristic of "take-all." Abundant mycelium was present on the bases of the stems of the diseased plants, and also perithecia with mature asci. The study of this material showed the fungus to be *Ophiobolus cariceti* (B. & Br.) Sacc.

Raspberry Diseases. G. H. BERKELEY and A. B. JACKSON.

The average amount of mosaic for the Niagara Peninsula is from fifteen to twenty per cent. There is less in the district around London, Ontario, many of the fields being free from the disease.

Nicotine sulphate may be used to check the spread of the disease. In unsprayed plantations the disease spread 5.3 per cent. In those sprayed twice the spread was only 3.8 per cent. Heavy fertilizing masked the presence of the disease. The chief method of control during the past two years has been the use of certified stock. A number of disease-free plantations have been found, and these together with others, having less than 3 per cent of mosaic furnish satisfactory stock. A grower may use his own stock by selecting only healthy shoots.

Leaf curl in the Niagara Peninsula varies from zero to five per cent. It is apparently on the decrease. Diseased plants are rogued as soon as noticed and the spread of this disease has been greatly checked.

Blue stem of red and black raspberry. G. H. BERKELEY and A. B. JACKSON.

In 1922 the presence of blue stem, as described by Lawrence, was reported on black

raspberries in the Niagara Peninsula. This year we have to report blue stem as prevalent throughout the Peninsula on both black and red raspberries. Three-fourths of the Cuthbert plantations showed the disease to be present, in some cases as high as 10 per cent. Affected plants show the typical blue-stem with accompanying defoliation; bronzing of the tip leaves and the blue discoloration of a portion or all of the stem. The tops become brown and withered. No fruit-bodies have been observed in the field.

Sections of diseased plants show the presence of mycelium in the wood elements. Internal isolations from infected canes give characteristic cultures of *Acrostolagmus caulophagus*, Lawrence.

Strawberry black root. G. H. BERKELEY and A. B. JACKSON.

In the past the cause of this trouble has been put down to winter injury. During the season of 1923 this trouble was fairly general in one or two districts of the Niagara Peninsula. Evidence, mainly of an observational nature has been brought forward which tends to show that there are three types of this black root injury. Further evidence, supported by preliminary inoculation tests, points out the possibility that at least one of these types of injury may be caused by soil bacteria.

Effects of salt and hydrogen-ion concentration upon the growth and structure of certain bacteria and moulds. GUILFORD B. REED.

The growth of *Vibrio comma* in dilute peptone is increased with the addition of NaCl up to 0.2 m. The addition of the salt widens the pH tolerance. Further increase in the concentration of NaCl decreases the growth and decreases the pH tolerance.

In very dilute NaCl and at optimum pH for growth the organisms are small regular cocci and rods, at pH higher or lower than optimum the organisms are larger and at the extremes of pH consist of large rods and yeast-like bodies. In the optimum NaCl concentration for growth the organisms are more nearly typical with less variation in structure at the extremes of pH. In concentrations of NaCl above optimum the organisms are all larger than the normal with conspicuous modifications in structure at the extreme of pH.

The growth of *Oidium lactis* is similarly influenced by salt concentration and pH. At optimum pH and salt concentrations for growth, some hyphae, but mostly yeast-like bodies are produced. At higher or lower pH salt concentration than optimum for growth more hyphae and fewer yeast-like cells are produced. At the extremes of pH and salt concentration only hyphae are produced.

Root rot and blight of canning peas. R. E. STONE.

In certain sections of Ontario peas are extensively grown both for canning purposes and for seed. In some of the pea-growing sections a disease known as root rot and as blight has caused serious loss.

Two fungi are closely associated with the disease both of which are capable of causing trouble. One fungus, a species of Fusarium, attacks the roots causing them to rot. The other fungus, a Pythium works near the soil surface producing a symptom resembling damping off. A Rhizoctonia is often associated with the two fungi just mentioned. The disease is carried over in the soil for several years.

An attempt is being made to secure disease-resistant strains of peas. Last year thirty-four strains were secured through the co-operation of Wisconsin Experiment Station and U. S. Department of Agriculture, and the Dominion Canners Seeds Limited. These strains were planted in a badly infested field.

The check plots and many of the selected strains were total failures. However three strains gave very good yields and two other selections gave fair yields.

The best yielding strains will be tested again and if satisfactory will be propagated. In the meantime experiments will be carried on to determine the length of time required to render an infested field safe for pea growing.

Metabolism in Botrytis. A. HUNTER and G. H. BERKELEY.

A study of the metabolism of four Botrytis forms of the *B. cinerea* group was carried out by analysis for total nitrogen, ammonia N., amino N., sugar content and titratable acidity of the medium along with total N., and dry weight values of the mycelium. The three media used were liquid synthetic media with the nitrogen source the only variable. The results given mainly in graph form show not only important and interesting aspects of metabolism, but in addition, the nature of the graphs clearly points out that two of the four forms are very closely related and comprise a group distinct from the other forms. This same grouping has been obtained from cultural studies under constant temperature conditions. A correlation between physiology and morphology, in so far as grouping of the forms is concerned, has been established.

Results of experiments to prevent potato Rhizoctonia. J. E. HOWITT.

These experiments have been carried on for five years. Each year plots of 1/100 acre were planted in the same field and on the same day. Results are shown by the following table:

Solution	No. of years	Time of immersion	Average amount of Rhizoctonia
1–2000	4	2 hours	10.14 per cent
1–2000	4	3 hours	6.37 per cent
1–1200	4	1 hour	6.97 per cent
Control	4		48.37 per cent
1–500	3	2 hours	.7 per cent
1–500	3	1 hour	none
Control	3		56.9 per cent
1–1000	2	2 hours	11.6 per cent
1–500	2	½ hour	1.65 per cent
Control	2		60.6 per cent

In 1922 all plots were free from Rhizoctonia and this year is not included in the table.

Conclusions

1. In Ontario corrosive sublimate materially reduces the amount of Rhizoctonia.
2. Stronger solutions than usually recommended can be used.
3. Corrosive sublimate, one part to five hundred for one or two hours eliminates Rhizoctonia under soil and climatic conditions occurring at Guelph, Ont.

Stereum sanguinolentum as the cause of "Sapin Rouge" or red heart rot of balsam. J. H. FAULL and MISS IRENE MOUNCE.

Because spruce is becoming scarce newsprint pulp industries are now using balsam for their supplies of raw material. Diseases of balsam have not been carefully studied. One very important disease of balsam is the trunk disease or heart rot of living trees. Fifty per cent or more of affected stems may be discarded as unmerchantable. The rot extends throughout the length of the trunk down to breast height. French Canadian lumberjacks call these trees "Sapin rouge." The disease has also been called "hemlock

rot of balsam.'' During 1923 the senior author concentrated on a study of heart rot in the field. These studies showed the association of the fruits of *Stereum sanguinolentum* with this decay. Test tube cultures from the red heart rot made in December, 1922, developed fruits of *Stereum sanguinolentum* in August, 1923.

The fungus fruits abundantly on dead trees and slash, and furnishes further reason for slash disposal. It is possible that living trees with this heart rot may be utilized for newspaper pulp.

The aecial stage of Hyalopsora aspidiotus (Peck) P. Magnus. J. H. FAULL and G. D. DARKER.

Ten species of Hyalopsora (Magnus, 1901) are reported by Sydow, all known from telial or uredinial stages only. *H. aspidiotus* (*Uredo polypodii* var. *Polypodii-dryopteridis* Moug. et Nestl. 1815) occurs frequently in some localities on *Phegopteris dryopteris* in Europe and North America. Foliage of *Abies balsamea* bearing pycnia on two-year-old needles, and peridermia and pycnia on needles in their third year were found by H. P. Bell and J. H. Faull in Ontario and Quebec, 1920, 1922 and 1923, and associated with *P. dryopteris* carrying Hyalopsora rust. Dr. Bell named the rust on balsam *Peridermium pycnoconspicuum*. Inoculations by Dr. Bell from the balsam to the fern, in 1922, indicate that *H. aspidiotus* and *P. pycnoconspicuum* were stages of the same rust. In 1923 inoculations by Faull and Darker confirm these conclusions. Twenty fronds were inoculated, thirty controls were kept. Lesions developed on all the inoculated fronds (249 primary infections in all). Uredinial pustules formed on most of them (283 pustules in all). The controls remained free, the period of incubation was 22 days, June 20th to July 12th.

Smut control experiments in hull-less oats during 1923. B. T. DICKSON, R. SUMMERBY and J. G. COULSON.

Plots were replicated four times. The results indicate that copper carbonate dust treatment is efficient in control and simple in application. The table summarizes the results at MacDonald College, Quebec, Canada.

Treatment	Germination in lab.	Total culm count	% Smut by total head count	Yield in B.P.A.	P. E.
Formalin sprinkle	77	4128	1.8	33.54	± 2.38
$CuSO_4$ Dip	83	3662	0.38	31.60	± 1.74
No treatment	93	6628	72.8	12.48	± 0.64
No. $CuCO_3$ Dust	93	3832	1.5	36.62	± 3.53
No treatment	93	7417	70.0	12.15	± 0.64
No. $CuSO_4$ lime dust	80	4404	1.45	38.56	± 3.28

The June number of Phytopathology was issued June 27.